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## THE ECLIPSES OF 1916.

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There will be five eclipses during the year 1916. The first three will be completely visible all over the United States, the fourth can be seen only in Australia and its adjacent waters, while the fifth, although the least in magnitude and confined to a small section of almost inaccessible ocean, is in many respects the most interesting eclipse that has occurred for a life time.

It is the purpose of this article to present some account of these eclipses.

### The Lunar Eclipse of January 20.

The first eclipse of the year will be a partial eclipse of the moon on the early morning of January 20. Figure 1 will tell us the particulars.

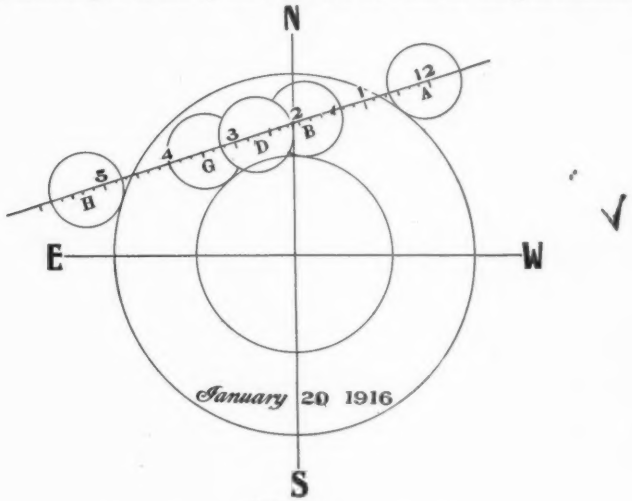


FIGURE 1.

PARTIAL ECLIPSE OF THE MOON JAN. 20, 1916

| | | Central Time |
|---|---|---|
| A | Moon enters Penumbra | 12:05 A.M. |
| B | Moon enters Shadow | 1:55 |
| D | Middle of Eclipse | 2:40 |
| G | Moon leaves shadow | 3:24 |
| H | Moon leaves Penumbra | 5:14 |

The largest circle in the diagram represents the earth's penumbra, and the next in size the earth's shadow, at the place where the moon crosses them. The letters N E S W are the points of the compass, which tell us to hold the diagram before us in such a way when looking at the moon, that the line NS points to the pole star. At midnight this line will be vertical with N on top. After that it will incline more and more to the right. We note that E is to the left in the sky, while on terrestrial maps it is towards the right. The long oblique line is the path of the moon, and gives the position of its center at intervals of ten minutes. The five equal small circles are five views of the moon at important moments. When its center is at A, at 12:05 A.M. central time, the Moon enters Penumbra. At B at 1:55, the Moon enters Shadow, and begins to be noticeably eclipsed, as if a piece had been cut off. At D at 2:40, we have the Middle of the Eclipse, when the Moon has entered deepest into the earth's shadow. Only fourteen percent of its diameter will then be eclipsed, so that it will not be worth the sacrifice of an hour's sleep to see it. At G at 3:24, the Moon leaves Shadow, and at A at 5:14 the Moon leaves Penumbra.

THE SOLAR ECLIPSE OF FEBRUARY 3.

The second eclipse will be an eclipse of the sun on the morning of February 3. Solar eclipses have been very rare of late in the United

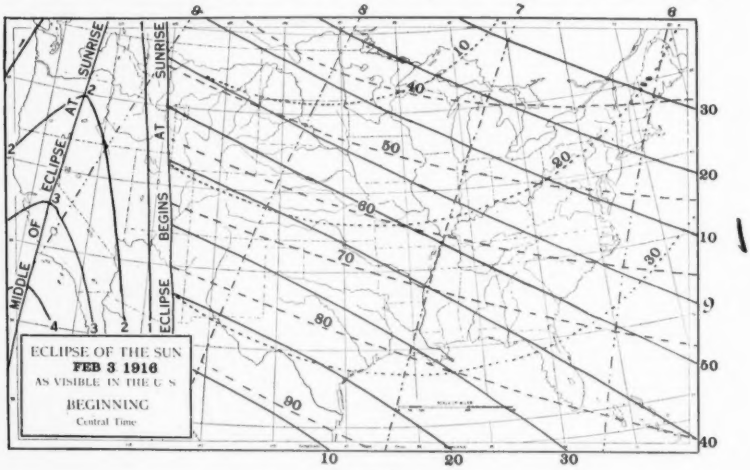


FIGURE 2.

States, so that this one will be most welcome. Let not the appearance of Figure 2 deter the reader from gathering for his own locality all the

information the map contains. With a little patience everything will be understood.

As the title indicates, Figure 2 refers to the beginning of the eclipse. The first thing of importance is the time. This is given at intervals of ten minutes and is shown by the full lines marked at the bottom and at the right of the map. The large 9 means 9 o'clock, central time, and the smaller numbers from 10 to 30 above and from 50 to 10 below the 9 indicate the minutes following and preceding 9 o'clock.

In looking for his own city, the reader may estimate its position in tenths of the distance of the lines on either side of it, and thus find the time to the nearest minute. He may practice the method by verifying 8:56 as the time when the eclipse begins at Omaha, and 9:07 as the time for Chicago.

The broken lines numbered 9, 8, 7, 6, on the top of the map, indicate the places at which sunrise occurs at 9, 8, 7, 6 o'clock central time. By remembering that each degree of longitude means four minutes of time, we can find the time of sunrise to the minute. This is 7:36 for Omaha and 7:05 for Chicago.

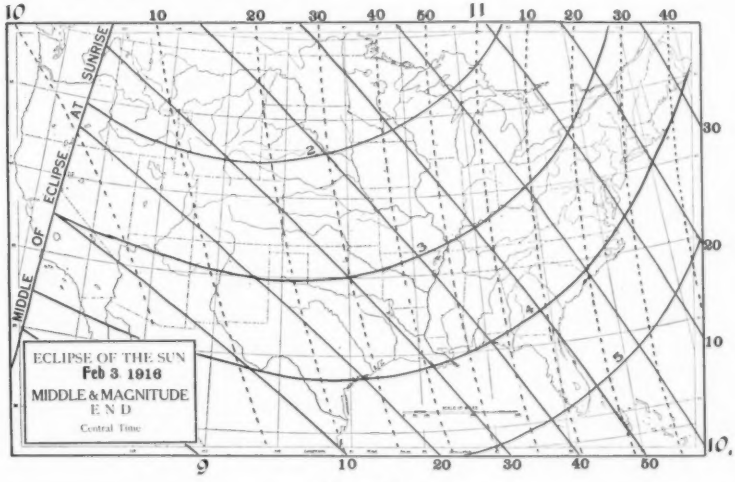


FIGURE 3.

Next to the time the most important fact to know is at what particular point the moon will first indent the sun. Let us imagine the lines NS and EW, on the diagram of the lunar eclipse in Figure 1, to be drawn on the sun as we look at it through a smoked glass, and then the whole circumference of the sun to be divided into 360 parts or degrees, as circles are always divided. Then the three dotted curves

on the eclipse map, marked 10, 20, 30, will tell us that for places situated on these lines the eclipse will begin at a point 10, 20, 30 degrees west of the sun's south point. For all other places we measure their proportional distances from these curves and get the "position angle" to the nearest degree. Thus at Omaha the "point of first contact" has a position angle of S 16° W.

It will be necessary, however, as in the case of the lunar eclipse, to incline the line NS, this time to the left, until it points to the north star, because the point on the sun nearest this star is the north point. As it may be difficult or even practically impossible to do this with precision, the eclipse map gives another set of curves marked from 40 to 90, in which the position angle is counted from the sun's lowermost point towards the right. For Omaha this angle is 54 degrees.

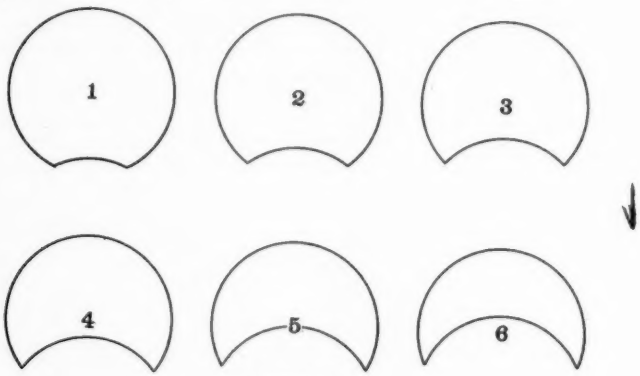


FIGURE 4.
APPEARANCE OF THE SUN AS VARIOUS TENTHS OF ITS DIAMETER ARE ECLIPSED.

Figure 3 will give us all the information we need in regard to the size of the eclipse, and the time of its middle and its end. The size or magnitude is indicated by the four full line curves marked 2, 3, 4, 5, which mean that for places on those lines the sun's diameter is eclipsed so many tenths. If we imagine a 0 after these numbers, we might say that they indicated the percentage of the obscuration. By measurement similar to that mentioned before, we see that at Omaha the magnitude of the eclipse is 23 percent.

In order to know what the sun will look like when 2, 3, 4, 5, tenths, or 20, 30, 40, 50 percent of its diameter are obscured, we turn to Figure 4 for the corresponding number. Intermediate ones, of course, we may estimate or draw. We can thus prepare a view of the eclipsed sun a long time in advance, and get it more accurate than we can observe it.

Coming back to Figure 3, we find that the time when the eclipse is greatest, or the time of the maximum obscuration, or that of the middle of the eclipse, is indicated by the numbers below the map and to its right. At Omaha this time is 9:41 or 9:42.

Finally, the dotted curves marked at the top show the time of the end of the eclipse, the time of "last contact". This is 10:34 for Omaha.

Our westernmost neighbors will not see the whole of the eclipse, because for them the eclipse will have already begun before the sun rises. This will be the case west of the line on Figure 2 marked "Eclipse begins at Sunrise". Another line marked "Middle of Eclipse at Sunrise" which is given on both maps, Figures 2 and 3, means that between the two lines mentioned the sun rises eclipsed to the extent indicated by the curves 1, 2, 3, 4 on Figure 2 which mean, as before, the tenths of obscuration, and that the eclipse will increase until it reaches the magnitude shown on Figure 3. West of the line "Middle of Eclipse at Sunrise" the sun rises eclipsed to the extent shown on Figure 2, but the eclipse will then be decreasing, its end occurring at the time indicated on Figure 3.

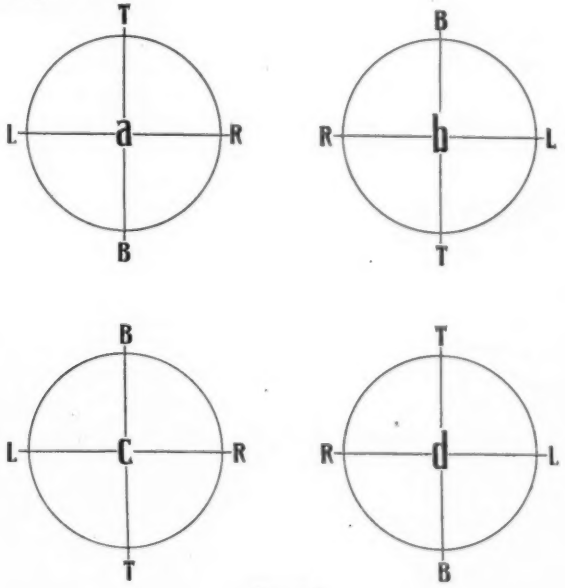


FIGURE 5.

In observing an eclipse of the sun, it is advisable to make use of a telescope of some sort, especially if we wish to note the exact moments of its beginning or of its end. The simplest kind of spyglass will do, if

we know how to use it. A few hints in that direction may be of service.

If our telescope shows terrestrial objects as they appear to the unaided eye, that is, up-side-up and right-side-right, we will see the sun's cardinal points N S E W correctly. Replacing these by the more convenient points T, B, R, L, top, bottom, right, left, we see the sun as drawn in Figure 5a. If we remove the inner pair of lenses from a common spyglass, we convert it into an astronomical telescope and see the sun inverted as in Figure 5b.

It is much better to project the sun's image on a piece of stiff white paper, than to look at it directly. With the smoked glass, which must always be used when we look at the sun directly, beginners will experience the greatest difficulty in finding the sun at all in the sky with the telescope. If we hold the paper or a card beyond the eyepiece and point the telescope to the sun, we will see the sun's image on the card, and may give it any size we please by holding the card at the proper distance and focusing accordingly. No dark glass is then necessary, and we have the convenience of being able to use both our eyes and of showing the image to an admiring circle of friends, all of whom may look at it at the same time. Supporting the telescope properly, and fastening the card to a light wooden rod and the latter to the telescope, will make observing easy and interesting. The points on the sun will then appear as in Figure 5c if we are using a spyglass, and as in Figure 5d, when we have an astronomical telescope.

We may even dispense with a telescope altogether. An image of the sun is formed on our card by any small hole in a piece of pasteboard, or even by the chinks in our window shutters provided we do not allow the sunlight to pass through the pane. The image will then be like Figure 5c.

If we practice any one of the methods just mentioned sometime before the eclipse, we may do some real scientific observing when the proper time comes. Having drawn a circle on our card with two diameters at right angles and having lettered their extremities T, B, L, R, according to the method we are using, we may also mark our point of first contact. Holding the card in proper position when the eclipse is about to begin, and making the sun's image coincide with our circle, we may observe the time of first contact within a few seconds. A string with a weight hung in front of the card will insure our holding the line BT correctly vertical.

### The Lunar Eclipse of July 14-15.

The third eclipse of the year will be a lunar eclipse on the night of July 14-15. It may be said in a way to be the complement of the one

of January 20 because then the magnitude was only fourteen per-cent, while in this eclipse it will be 80. Figure 6 will give the particulars.

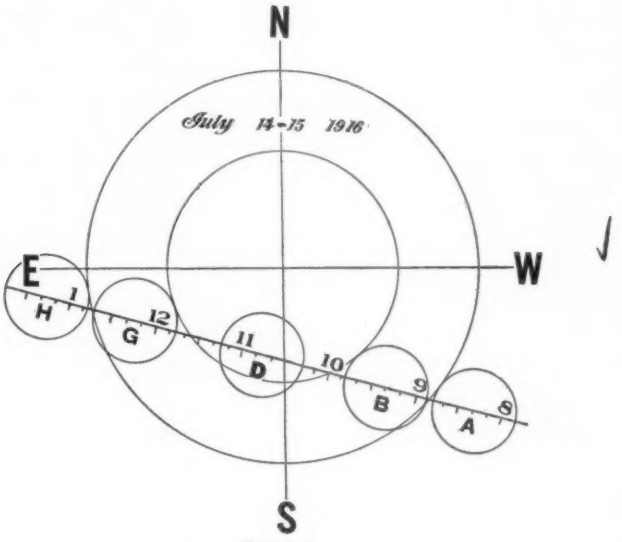


FIGURE 6.

PARTIAL ECLIPSE OF THE MOON JULY 14-15, 1916.

| | | Central Time |
|---|---|---|
| A | Moon enters Penumbra | 8:18 P.M. |
| B | Moon enters Shadow | 9:19 |
| D | Middle of the Eclipse | 10:46 |
| G | Moon leaves Shadow | 12:12 A.M. |
| H | Moon leaves Penumbra | 1:14 |

The two largest circles represent as usual the earth's penumbra and shadow, and N E S W mark the cardinal points. The eclipse begins at 8:18 P. M. central time, when the Moon enters Penumbra with its center at the point A. At 9:19 the Moon enters Shadow. At 10:46 we have the Middle of the Eclipse. At 12:12 A.M. the Moon leaves Shadow and at 1:14 A. M. the Moon leaves penumbra.

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The fourth eclipse of the year will be a solar eclipse on July 29, and will be visible, as said before, in Australia and its adjacent waters. As this eclipse is of no special interest to us in any way, we pass it over.

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### Eclipse of the Christmas Midnight Sun.*

The most remarkable eclipse in a certain way that can possibly occur, is the one that will come when we are busily preparing for Christmas, that is, when our clocks show 3 P.M. central time on Christmas eve. We in the United States will not even get a glimpse of it nor will any one in the whole of North and South America, nor in the wide extent of the Pacific Ocean. For us and for all these lands and seas the sun will be shining undimmed in its full splendor, as far as the weather and the season permit. But far away in the Antarctic Ocean, about half way between the Cape of Good Hope and the South Pole, over a limited tract of unfrequented waters, the sun will be eclipsed to such a tiny extent, a trifle over one percent, that it seems to be a downright waste of time, if not absolute folly, to mention it at all. But for the ships that may be there to see it, the eclipse will occur when some of them have midnight, Christmas midnight, while others have any hour or minute on Christmas eve from 9:41 P. M. to midnight, and a few have already for a few minutes after midnight begun Christmas day.

Look at Figure 7 for the explanation. Here we have the earth, the sunlit hemisphere, as it will appear to the sun at 2:40 P. M. central time. The sun will then be overhead in the centre of the figure, in latitude 23° 25′ south, and in longitude 130° west. The greater part of North America, and all except the extreme eastern part of South America, the whole Pacific Ocean and a part of Australia, will then have day. As the earth is turning eastward on its axis, that is, towards the right in the diagram, the sun will be setting all along the entire right half of the circle that is seen to bound the terrestrial globe in Figure 7, and rising all along its left half. The north pole is not visible, it is in the middle of its six months darkness. The south pole, however, is in full view, and as the date is but a few days after the winter solstice, the sun's rays shine 23 degrees and 25 minutes beyond the south pole, so that if the earth did not move in an orbit around the sun, but only turned on its axis, all the sunlit region about the south pole would have perpetual day.

The line N S crossing the earth is the central meridian, the only one of all the meridians on the earth to be projected into a straight line at the time mentioned, when our clocks show 2:40 P. M. central time on Christmas eve. Its longitude, as said before, is 130° west. All along that line it is noon. If we were to start at the very top of the figure near the letter N in latitude 66° 35′ north, the sun would be seen to

* Read at the California meeting of the American Astronomical Society, Berkeley, August 5, 1915.

just rise above the southern horizon at midday. For every degree of latitude that we go south on this central meridian, the sun is one degree higher at noon, and the day is getting longer. From a few minutes in

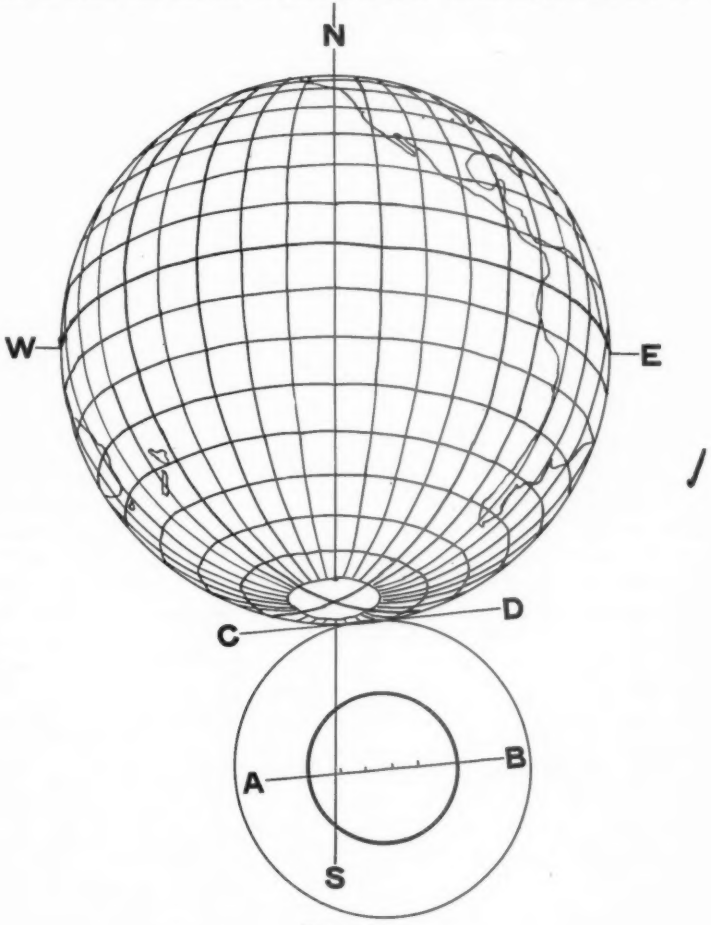


FIGURE 7.
SOLAR ECLIPSE OF DECEMBER 24-25, 1916.

latitude 66° 35′ north, it lengthens to 12 hours at the equator. where its length never changes all the year round. When we come to latitude 23° 25′ south, to the place in the exact centre of the diagram, the sun is directly overhead. As we proceed southward, the sun begins to sink towards the north. The day is all the time lengthening and becomes

equal to 24 hours as we reach the latitude 66° 35′ south, beyond which it lengthens rapidly until it becomes six months long at the pole.

As soon as we arrive at the south pole, there is no direction but north, since we cannot possibly go farther south than the south pole, and when we have reached it, any further motion must take us away from it, that is, carry us north. Hence as soon as we have passed the south pole, while we continue on our straight line or on our great circle, we are going north, the sun is now south of us, instead of

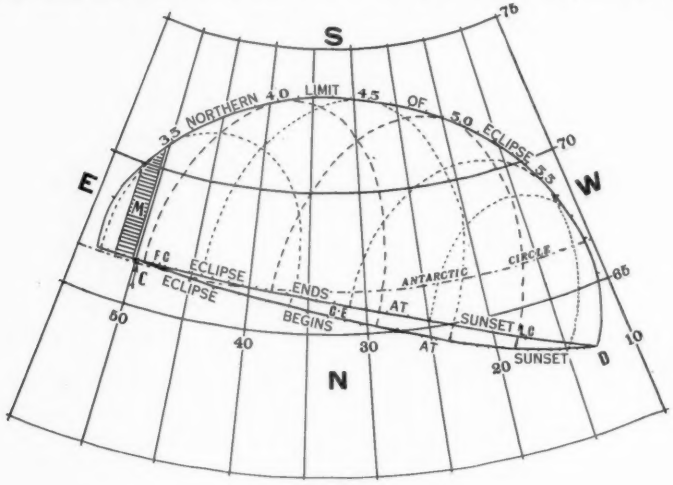


FIGURE 8.
MAP OF THE SOLAR ECLIPSE OF DEC. 24-25, 1916.

north, as it was before, and noon has changed to midnight. The sun is visible until we come to 66° 35′ south latitude, the lowermost point on our diagram, when it will sink below the south horizon. All the way between this latitude and the pole, we can see the sun at midnight. As we leave this limit, that is proceed on our northward journey past the lowermost point on the diagram and enter the dark hemisphere, the sun begins to dip more and more below the south horizon at midnight. And all that has been said about our journey from 66° 35′ north latitude across the sunlight hemisphere towards 66° 35′ south latitude beyond the south pole, will be repeated in the same order if we exchange night and day, and north and south.

I must call attention to another fact, that is as soon as we passed the south pole, our meridian changed 180 degrees, from being 130 degrees west, it becomes 50 degrees east. We will need all these facts to understand the exceptional circumstances of the present eclipse.

The reader will also notice that only two meridians have been drawn across the south pole for the region within ten degrees of it. This was done to avoid confusion, since all the meridians meet at the poles. The two, or we may say, the four that are drawn, are first, the meridian of Greenwich, which is the one to the right and below, and quickly enters the dark hemisphere. The second one, the upper one to the right, is the 90th meridian, which we may trace through the middle of the Gulf of Mexico and the United States, and which is our own standard meridian and gives us central time, this being six hours slow of Greenwich. The next one on the diagram is the 180th meridian, on which all mariners change their date, dropping a day when going west and repeating it when going east. The last meridian drawn across the south pole, the lower one to the left, is the 90th east of Greenwich.

We may now turn our attention to the two circles below the terrestrial sphere on Figure 7. The smaller one is the moon. Its centre moves along the line AB, where its position is given for every ten minutes during the eclipse time, from 2:30 P. M. central time, on the first mark to the left, near the line N S, to 3:00 o'clock, on the last mark to the right.

The larger circle is the moon's penumbra, which is of great import ance in every solar eclipse. To understand its nature and its action, I must ask the reader to try with me a very instructive experiment. Let us place a piece of white paper in direct sunlight and hold a small ball to the paper. We notice that the shadow is black and sharp and as large as the ball. As we separate the ball and paper, the shadow becomes more and more indistinct at the edge. The true shadow we call the umbra, and the indistinct part the penumbra. When we have separated our ball and paper so far that their distance apart is 114 times the size of the ball, the umbra has diminished to a point and the penumbra has grown to have a diameter twice as large as the ball. If our ball is as large as the moon on Figure 7, and is held at a distance of 114 times its diameter from the figure, its shadow or umbra will be the point on the line AB which is at the time 2:46, while the penumbra will be the outer and larger circle. We will not be able to see the umbra and penumbra on our paper, because the first is a point and the second is too faint, but they are really there, notwithstanding. We can actually see them or their effects very accurately if we put our eye in the place of the paper and look at the ball, taking the precaution to use a smoked glass. When our eye is exactly on the circumference or edge of the penumbra, we will see our ball apparently touching the sun. This astronomers call contact, first contact when the eclipse begins, last contact when it ends. As we move our eye along, or better, as our moon, the ball, moves across the sun, we will see the sun

obscured more and more, until it is completely covered and we have a total eclipse.

Now as the moon's distance from the earth may vary about sixteen percent, the moon when far away appears smaller than usual and cannot cover the whole sun, whereas when near it appears larger and can more than cover the whole sun. In the first case, the point of the moon's shadow, the apex of the shadow cone, does not reach the earth; the sun appears as a ring of light about the black moon, and we have an annular or ring eclipse. In the second case the apex of the shadow would penetrate the earth if the latter were transparent, or which amounts to the same thing, the moon's shadow on the earth is of some size, and everyone that chances to be in it sees the sun totally eclipsed.

After this probably long, but necessary, preamble we are prepared to understand the exceptional conditions of the present eclipse. In an ordinary solar eclipse the path of the moon, AB on Figure 7, lies across some part of the earth, so that the places so situated may see a total or an annular solar eclipse. Every place inside the penumbra sees the sun partially eclipsed, the magnitude increasing almost in a direct ratio to nearness to its centre. Every place on the forward edge of the penumbra has first contact at the same moment, every place on its retreating side has last contact.

In some eclipses the central line does not fall on the earth at all, so that the eclipse is only a partial one everywhere. In the present eclipse the moon's path AB is so far off the earth that the penumbra does little more than graze the earth, covering it to the extent of only 0.008 of its radius, that is, only about 32 miles. This is the first most exceptional fact connected with the present eclipse, and has never happened before during the 33 years that the writer has studied eclipses.

The moment at which the penumbral circle overlaps the earth most is 2:46 P. M. central time. The diagram Figure 7 shows the penumbra in this position. As this is six minutes later than the time for which the terrestrial meridians were drawn, the earth has turned one and a half degrees more, so that the longitude of the central meridian at this time is 131½ instead of 130 degrees. The difference is hardly noticeable. If the penumbra had been drawn for the time 2:40, instead of 2:46, it would overlap the earth so little less that even a magnifying glass would not show the difference. In fact, the line CD which is parallel to AB and tangent to the penumbra, as well as the edges of the penumbra and earth, are all so close together that they practically coincide.

The second exceptional peculiarity of the present eclipse, is the fact of the penumbra's falling beyond the south pole, where on the diagram north and south exchange names, and east and west as well. For this reason, the penumbra moves *against* the diurnal motion of the earth and therefore shortens the duration of the eclipse, whereas if it were placed higher up on the diagram it would move *with* the earth, as it generally does, and lengthen the time of the eclipse.

Thirdly, the line CD, the "Northern Limit of the Eclipse," enters upon the earth at a point to the left of the line NS, so that CD crosses NS on the earth's disk. As the local time on this part of the line NS is midnight, there is in fact an eclipse of the midnight sun. That the line CD does really enter the terrestrial sphere at the place mentioned, as well as all the other data that are necessary for the construction of the eclipse map, could never be known by even a microscopic examination of Figure 7. Recourse had to be had to rigorous and lengthy calculations, which alone could ferret out the desired knowledge. Deriving the necessary data from a diagram like Figure 7 is always a very easy and expeditious method, when the penumbra crosses the earth somewhat centrally, and was the one used for the eclipse of February 3 given at the beginning of this article. Here, however, the graphic method fails utterly,—another peculiarity of the present eclipse which specialists will appreciate.

Fourthly and lastly, perhaps the most exceptional peculiarity of the present eclipse is the fact of its occurring for most places within the eclipse region on Christmas eve, for some at Christmas midnight. and for some others on Christmas morn.

In order to bring this rather lengthy article to a close, let us look at Figure 8, the eclipse map, and see what wonderful facts calculation has elicited from that minute portion of Figure 7, where the moon's penumbra passes across the earth's disk.

The first thing we notice on the map, Figure 8, is that south is on top and west to the right, in other words, that the map has been apparently reversed. This was done on purpose in order to facilitate comparisons of Figures 7 and 8. The numbers 50, 40, 30, 20, 10 below, mean the degrees of east longitude, and 75, 70, 65 to the right the degrees of south latitude. The broken parallel of latitude is the Antarctic Circle.

The point C is where the line CD of Figure 7 enters the earth, and the point D where it leaves it. The half ellipse marked "Northern Limit of Eclipse" is the projection of the straight line CD of Figure 7 on the spherical earth, distorted partly by its rotation. The point FC on Figure 8 is the place of "First Contact", the very first place on earth to see the eclipse begin, and LC that of "Last Contact", the very last

to see it end. The point GE is the place of the "Greatest Eclipse", where one percent of the sun's diameter is covered by the moon. The dotted curves tangent to the "Northern Limit" at the numbers 35, 40 and so on, are successive projections of the circular rim of the moon's penumbra at the corresponding minutes after 2 P. M. central time. The last one to the right, however, is the one for 2:59. The eclipse begins at those minutes all along the western portion of the curve from the number on the "Northern Limit" line to the curve "Eclipse begins at Sunset", and ends along the eastern portion from this same number to the curve "Eclipse ends at Sunset". The penumbra moves westward, as was said before, instead of eastward as in all other eclipses.

The shaded portion near the letter M shows the region where the Christmas midnight sun will be eclipsed. To the right of this region the eclipse occurs between 9:41 P.M. and midnight, local time, on Christmas eve; to the left of it after midnight on Christmas morn. The longest duration of the eclipse at any one place is 17 minutes. For the whole region, or as astronomers say, for the earth generally, it is 28 minutes, from the moment of First Contact at 2:32 P. M., central time, when the eclipse begins at the point FC, to 3:00, the moment of Last Contact, when it ends at the point LC.

Creighton University Observatory,
Omaha, Nebr.

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## THE GIANT SUN CANOPUS.

CHARLES NEVERS HOLMES.

Most of us have never seen the great southern sun Canopus, about which many of us know far less than we should; and a translation of a part of an article by the famous French astronomer, M. Camille Flammarion, which appeared in *L'Astronomie*, January, 1915, presents many interesting and instructive facts about "Le Soleil Géant Canopus,"

"The barbaric follies of our wretched terrestrial human nature should not cloud from our minds the splendors of celestial contemplation. If our planet should be inhabited during some ten millions of years, according to astronomical and geographical agreements, and if humanity is not yet older than four hundred thousands of years at the most, she has not yet passed her fourth year relative to the age of normal life; and her unconscious cruelties are to be explained as those of children. She will go through evolutions in the future.

"We are able to estimate within two or three thousands the number of thinking creatures, comparatively well-educated, and intellectually alive. This number would represent about five millions of intelligent, wise men upon the terrestrial globe: this is probably exaggerated; but let us admit it.

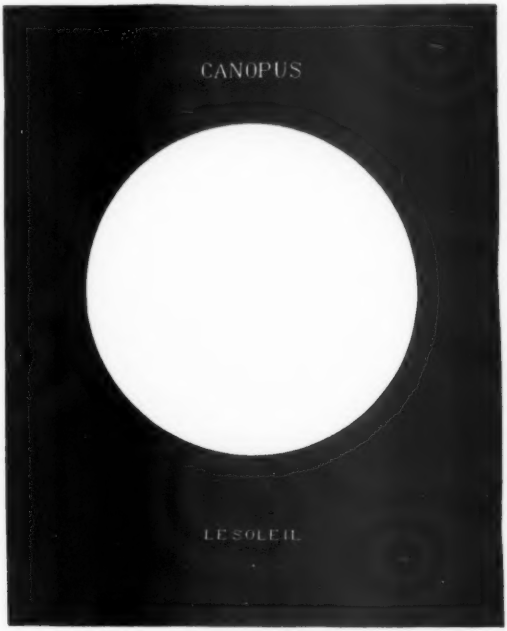


FIG. 1. COMPARATIVE SIZE OF CANOPUS AND THE SUN (LE SOLEIL).

"It is with this class of minds that we speak here. They have grown up more quickly than the mass, they have gone through evolutions, *they think.*

"Of all sciences, Astronomy is, without comparison with any other, that which develops most our conceptions and which frees us most from the gross attachments of matter. It is beautiful, it is consoling, to see in the observatories of the whole world patient searchers penetrating more and more deeply the secrets of the Universe and discovering gradually the mysteries hidden in the majesty of theories.

"Our readers know the most stupendous of all the suns of the infinite visited by our telescopes, that grand, that almost fabulous CANOPUS, the star Alpha of the constellation of The Ship, concerning which we

have often spoken in these pages, for more than a third of a century. According to the closest estimate, his surface surpasses that of the sun some 18,000 times, his diameter some 134 times, and his volume some 2,420,000 times that of our furnace.

FIG. 2. COMPARATIVE SIZE OF THE SUN (LE SOLEIL) AND THE EARTH (LA TERRE)

"Numbers do not present to the mind striking pictures comparable with those of the drawing. That is why it has seemed advantageous to me to draw for our readers two figures to represent these numbers. In the first, the sun being represented by a disk of a half-millimeter,* Canopus with a diameter 134 times greater; in the second, the sun is

* In reproducing these pictures our engravers unfortunately have reduced them to smaller scales. The relative sizes are however correctly given. [EDITOR POPULAR ASTRONOMY.]

in his turn drawn in his exact proportion with the earth, that is to say, with a diameter 109 times larger than that of our Planet, represented by a disk of a half-millimeter. These drawings, very simple, are prodigious and eloquent.

"The most precise researches indicate that this star of first magnitude, nevertheless for us inferior in brilliancy to Sirius (— 1.0, Sirius being —1.6) is incomparably more remote from us than Sirius, his most probable parallax being about 0″.007 and that of Sirius 0″.37. This gigantic sun would be 49,700 times brighter than our pale furnace. There would result from this, as we have just stated it; for his surface 18,000 times that of the sun, for his diameter 134 times, and for his volume 2,420,000 times that of the sun.

"An English astronomer, M. O. R. Walkey, has just calculated, according to a mass of very curious probabilities, that this truly formidable star can be the center of our sidereal universe. Its mass would surpass by a million and a half times that of our furnace."

Hotel Nottingham,
Boston, Mass.

## THE GRAPHICAL COMPUTATION OF TRANSIT FACTORS.

THORNTON C. FRY.

In the use of the transit instrument, Mayer's equation

$$\Delta T + Aa + Bb + Cc = \alpha - T$$

is involved. The coefficients, $A$, $B$, and $C$, of this equation are functions of both the latitude, $\phi$, of the place of observation and the declination, $\delta$, of the star observed. They are given by the equations

$$A = \sin(\phi - \delta) \sec \delta,$$
$$B = \cos(\phi - \delta) \sec \delta,$$
$$C = \sec \delta.$$

For work at a fixed observatory these coefficients may conveniently be tabulated, as they then depend on a single argument, $\delta$. But when observations are to be taken at various places, the tables become long and their use laborious, owing to the double interpolation involved. If, as frequently happens, more than two places of decimals is not required, the following graphical tabulation may be used to advantage. The writer makes no pretence to originality of method. He believes, however, that the general theory * has not heretofore been recognized as applicable to the above equations.

* For the general theory, see D'Ocagne, "Traité de Nomographie," Chapitre III.

For any given value of $\phi$, the following construction may be carried out: Let a scale of values of the declination $\delta$ be constructed in any convenient manner along a line $CD$, Figure 1. Further, let a parallel $AB$ be drawn, and an arbitrary point $P$ chosen. Lines may now be drawn joining $P$ with various points $\delta_1, \delta_2, \delta_3, \ldots$, on the scale $CD$. By noting the intersections of these lines with $AB$ and marking them with the corresponding values, $A_1, A_2, A_3, \ldots$, of $A$, a second scale is formed. If the position of $P$ is changed a different chart is obtained.

These facts may be restated as follows: If $\phi$ be given a fixed value it is possible to choose scales $AB$ and $CD$ so that all lines joining corresponding values of $A$ and $\delta$ pass through a common point, $P$. Moreover, this choice can be made in a great variety of ways.

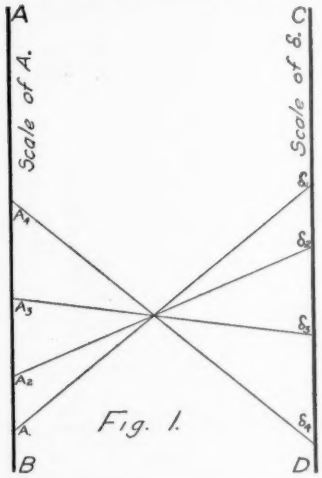

Fig. 1.

For each new value given $\phi$ a new chart may be constructed, but to construct many such charts is not feasible. The variety of charts possible for any one value of $\phi$ suggests the question: Is it possible so to choose a pair of scales $AB$ and $CD$, that, for each fixed value of $\phi$ which may subsequently be assumed, lines joining corresponding values of $\delta$ and $A$ on this chosen pair of scales will pass through a common point? The advantage of such an arrangement is obvious. The scales $AB$ and $CD$ being constructed once for all, it is only necessary to indicate the position of the point $P$ corresponding to each value of $\phi$ in order that the single chart may be of service at various stations, that is, for various values of $\phi$.

To secure the desired result is possible in only one way. The scale $CD$ must be so numbered that the distance of any number $\delta$ from the zero of the scale shall be equal to the tangent of $\delta$. The scale $AB$ must be uniform. The points $P$ corresponding to various values of $\phi$ then arrange themselves upon a smooth curve.*

* In a very special case the curve is a parabola. Generally it is a hyperbola, whose transverse axis joins the zero points of $AB$ and $CD$; whose vertex is $\frac{2}{3}$ the distance from $AB$ to $CD$, and which passes through the points $+1$ and $-1$ on $AB$. These facts may be proved by the use of "line coördinates." See D'Ocagne, loc. cit.

A proof may also be effected *a posteriori* by setting up the equation of a line passing through the point $P$ and proving that it intersects $AB$ and $CD$ in correspondingly numbered points.

The chart shown in Figure 2 was constructed in this manner. The actual labor is as follows: The scales $AB$ and $CD$ are first divided as explained above. Then pairs of values of $\delta$ and $A$ are found for each desired value of $\phi$.*

Each pair determines a line, and the intersection of two such lines is $P$. Finally each $P$ is marked with the value of $\phi$ corresponding to it, and all are joined by a smooth curve. The construction for $A$ is then complete.

To obtain a chart of the values of $B$ a new scale is constructed along the hyperbola already drawn, with values of $\underline{\phi}$ given by the equation

$$\underline{\phi} = \phi + 90^\circ \quad \text{or} \quad \phi = \underline{\phi} - 90^\circ.$$

For readings on this scale

$$A = \sin(\phi - \delta)\sec\delta = -\cos(\underline{\phi} - \delta)\sec\delta.$$

the negative of which is the value of $B$ corresponding to $\underline{\phi}$. For convenience a set of negatives of the numbers on the A-scale are arranged under the heading $\underline{B}$, so that $B$ may be read directly. These numbers, and those corresponding to $\underline{\phi}$, are underlined† to avoid confusion.

$C$ is a function of $\delta$ only, and to give a graphical representation of $C$ requires only that each value of $C$ be written directly opposite the $\delta$ to which it corresponds.‡

The use of the drawing may best be illustrated by an example. Find $A$, $B$ and $C$ if $\phi = 45^\circ$, $\delta = 37^\circ$. A black thread is first tightly drawn connecting $\phi = 45^\circ$ and $\delta = 37^\circ$. $A$ is read off as $+0.18$.

The thread is then moved to join $\underline{\phi} = 45^\circ$, $\delta = 37^\circ$, and $\underline{B}$ read off as $+1.24$. For this purpose the underlined figures are used for both $\phi$ and $B$.

$C$ is read directly opposite $\delta$ as $+1.25$.

Computation gives: $A = +0.174$, $B = +1.240$, $C = +1.252$. It will be found on trial with an accurately constructed drawing of moderate size, say 8″ x 10″, that results of such accuracy are to be expected.

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* In practice it is well to note that, if $A = 0$, $\delta = \phi$, and if $\delta = 0$, $A = \sin\phi$. When the point of intersection of the lines determined by these pairs may be easily located, they should be used. It is always advisable to compute a third pair of values to check the accuracy of the work.

† In practice it is better to use ink of a different color.

‡ This is most easily accomplished by noting that the height from the zero point to any value $s$ of sec $\delta$ is given by

$$h = \tan\delta = \sqrt{\sec^2\delta - 1} = \sqrt{s^2 - 1}.$$

Thus, the height of the number 2 is $\sqrt{3}$.

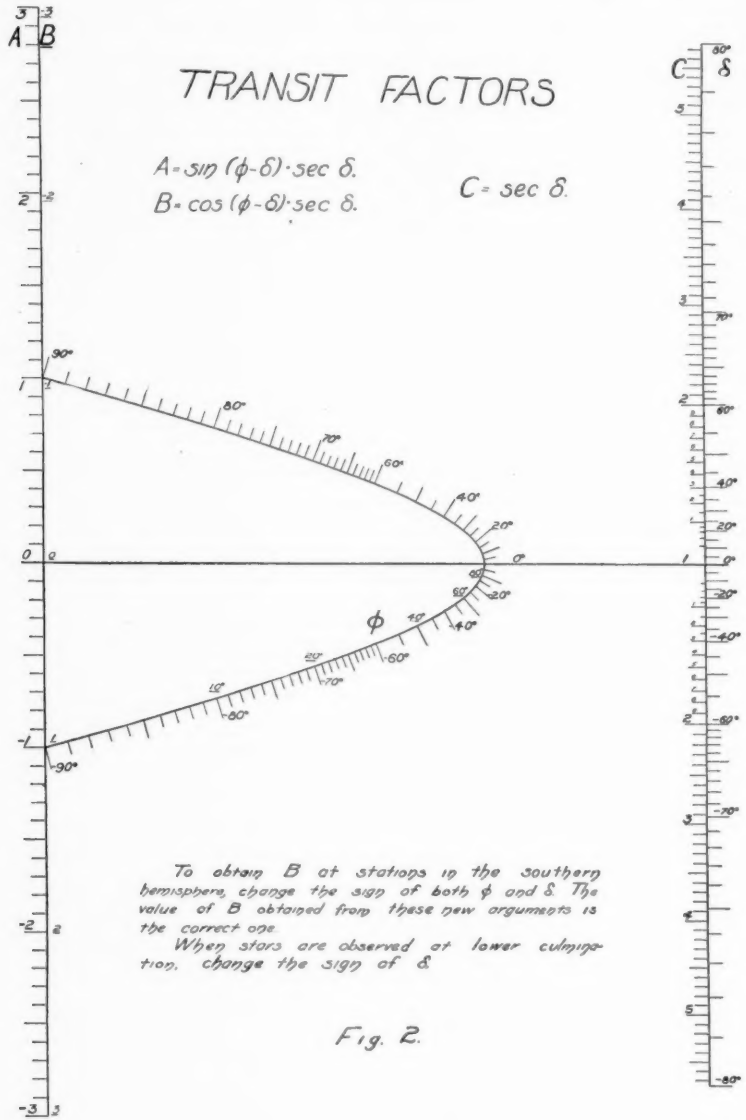

TRANSIT FACTORS
A = sin (φ-δ)·sec δ.
B = cos (φ-δ)·sec δ.
C = sec δ.
A
B
C
δ
φ
To obtain B at stations in the southern hemisphere, change the sign of both φ and δ. The value of B obtained from these new arguments is the correct one.
When stars are observed at lower culmination, change the sign of δ.

Fig. 2.

It must not be inferred that, because the scale interval between successive values of $\phi$ and $\delta$ at places is small, accuracy is impaired. Quite the converse is true. For, although it is impossible to distinguish accurately between 37° and 37° 15′, this very fact is only a graphical indication that, so far as values of $A$ and $B$ are concerned, slight variations in latitude are inconsequential when the latitude is not far from 37°. In the interest of accuracy it is important that the $A$, $B$ and $C$ scales may be read with equal ease at all points. A glance at Figure 2 will show that this condition is fortunately satisfied.

To find the value of $B$ for observations taken at stations in the southern hemisphere, it is necessary to change the sign of both $\phi$ and $\delta$. The reader can easily verify that this leaves $B$ unchanged. This change is rendered necessary by the fact that negative values of $\phi$ occur on an infinite branch of the hyperbola, and cannot therefore be included in the chart.

To apply the chart to stars at lower culmination, it is only necessary to use $-\delta$ in place of $+\delta$. For such observations the sign of $C$ is reversed according to the usual rule.

The following values of $A$ computed from the chart of Figure 2 indicate the accuracy of the method:

| $\delta$ | $\phi$ | $A$ (from chart) | $A$ (computed) | Error |
|---|---|---|---|---|
| 75° | 45° | −1.94 | −1.932 | +0.008 |
| −20 | 45 | +0.96 | +0.964 | +0.004 |
| −10 | 60 | +0.96 | +0.954 | −0.006 |
| 74 | −50 | −3.01 | −3.008 | +0.002 |
| 60 | −10 | −1.88 | −1.879 | +0.001 |
| 37 | 45 | +0.18 | +0.174 | −0.006 |

University of Wisconsin,
October, 1915.

# THE HISTORY OF THE DISCOVERY OF THE SOLAR SPOTS.

WALTER M. MITCHELL.

## Preface and Introduction.

A perusal of the various histories and treatises on astronomy, in the quest for information on the subject of this research, showed most clearly that there was still opportunity for investigation, and that the question of the identity of the first observer of the solar spots was by no means settled. It was with the intention of ascertaining just how much could be learned that I entered upon this task. It has proved longer than was anticipated, but it is believed that the subject is of sufficient interest to warrant translating and presenting in English the early publications and letters, from which sources the information is to be obtained.

It is now more than three hundred years since the first telescopic observations of the spots were made, and during this interval many of the original manuscripts and letters, which might have yielded valuable information on questionable points, must doubtless have become lost. Consequently a reasonable skepticism toward any attempt to fix the discoverer of the solar spots is to be expected. In view of this, the only attempt that can be considered advisable is to present such facts and evidence as are in our possession at the present time, and to draw such conclusions from them as seem justified.

It is well known that spots were seen on the sun long before the invention of the telescope. In this paper no attempt will be made to discuss these pre-telescopic observations; the discussion will be confined entirely to the earliest observations with the telescope.

The principal memoirs and writings on the subject, which may be consulted with profit, and to which frequent reference will be made, are the following:

*Notices Biographique, Galileo.* Oeuvres de Francois Arago. Tome III, pp. 270-282. Paris, 1855.

*Réflexions sur les Objections soulevées par Arago contre la priorité de Galilée pour la double découverte des taches solaires noires, et de la rotation uniform du globe du Soleil.* Par Jean Plana. Memorie della Reale Accademia delle Scienze di Torino. Serie II. Tomo XX, pp. 151-187. Torino, 1863.

*Sulla Priorita della Scoperta e della Osservatione delle Macchie Solari.* Miscellanea Galiliana Inidita. Antonio Favaro. Memorie del Reale Istituto Veneto de Scienze, Lettere ed Arti. Volume XXII, pp. 729-783. Venezia, 1882,

*Christoph Scheiner als Mathematiker, Physiker und Astronom.* Anton von Braunmühl. Bayerische Bibliothek. Band 24, Bamberg 1891.

*Der Magister Johann Fabricius und die Sonnenflecken, nebst einem excurse über David Fabricius.* Eine Studie von Gerhard Berthold. Leipzig, 1894.

*P. Christoph Scheiner, S. J. und seine Sonnenbeobachtungen,* P. Joh. Schreiber, S. J. Natur und Offenbarung. Band 48. Münster, 1902.

*L' 'Unicuique Suum' nella Scoperta delle Macchie Solari.* Per. P. Bellino Carrara, S. J. Memorie della Pontificia Accademia Romana del Nuovi Lincei. Volume XXIII, pp. 191-287. Volume XXIV, pp. 47-127. Roma, 1905-6.

Mention should also be made of the magnificent *Edizione Nazionale delle Opere di Galileo Galilei,* in twenty volumes, published at Florence under the auspices of His Majesty the King of Italy during the years 1890-1909. This monumental work, which has been prepared and edited chiefly through the labors of Professor Antonio Favaro, is an almost inexhaustible storehouse of information concerning the writings and life of Galileo and his contemporaries.

Throughout the following pages, in the translations of the quotations from the cited references, the object has been to give a literal translation that would express as closely as possible the meaning of the original, rather than to attempt a free translation in more elegant English with the consequent sacrifice in accuracy.

The imperfections in what follows would have been many more but for the assistance of kind friends. I wish to express my most sincere appreciation and thanks to those who have given such generous assistance with the numerous translations, in particular to Dr. H. L. Crosby of the University of Pennsylvania, and to Drs. Herbert D. Austin and Percival B. Fay of the University of Michigan.

In order better to understand the difficulties encountered by the scientific investigator at the beginning of the seventeenth century, and the events which will be described later on, it will be advisable, before discussing the discovery of the solar spots, to outline briefly the condition of astronomical thought in Europe at that time, and to trace the course of events which had given rise to that condition.

The two chief problems of astronomy which had occupied men's minds since the early days when astronomy was thought of at all were the shape of the earth and the motions of the heavenly bodies, in particular the motions of the planets. The ideas extant in Europe had been derived in the main from the ancient Greek writers. Of these, the two whose writings maintained the greatest influence were unquestionably Aristotle and Ptolemy. The great influence of Aristotle and the

veneration in which his writings were held, is easy to understand when we realize that he was the first, and for many years the only one to attempt to systematize the whole amount of knowledge accessible to mankind. The Aristotelean system of the World distinguished sharply between the heavens, the region of unchangeable order and perfection, in which the incorruptible heavenly bodies moved with perfect circular motions; and the earth, the region of instability and change placed immovable at the center of the universe. Unfortunately the Greek astronomy of Aristotle's time was, as it were, crystallized in his writings, which thus became somewhat encyclopedic in character, and his great authority was invoked centuries afterward by comparatively unintelligent or ignorant disciples in support of doctrines plausible enough in his time, but which subsequent research was showing to be untenable.

As Aristotle had summed up the state of knowledge in his time, so Ptolemy, five centuries later, in his great work the *Almagest*, presented a complete treatise embracing the entire range of astronomical science. Altho the system of the World as conceived by Ptolemy was a mere geometrical representation of the celestial motions and did not propose to give a correct picture of the actual state of affairs, it remained for many hundred years the alpha and omega of theoretical astronomy. Throughout the Middle Ages Ptolemy's authority was regarded as almost final in astronomical matters, excepting where it was outweighed by the even greater authority assigned to Aristotle.

Greek astronomy practically ended with Ptolemy, the last great writer of the Alexandrian School. The few writers after his time were commentators and compilers, to none of whom ideas of any importance can be attributed. When the invading barbarians descended from the north, destroying Rome, Greek and Roman civilization were for the time put to an end. Ruin and devastation reigned everywhere. The conquerers seemed to be wholly untouched by the ancient culture of of Asia or anything that might be learned from their new subjects. To some extent their savage state became softened by the Christian religion which they gradually adopted, but above all there was a distinct lack of sympathy for anything that emanated from the heathen Greek and Roman world. But even before the fall of the Roman Empire, a fierce onslaught had commenced on the results of Greek thought. With the spread of Christianity came the determination to have nothing to do with anything that came from the Pagan Pre-Christian world. The great library at Alexandria, collected by the Ptolemies, was burned by the Christian mob under the turbulent Theophilus (389 A. D.). A few years later, Hypatia, the daughter of

Theon, herself a writer on astronomy, was barbarously murdered at the instigation of the bigoted Cyril, and the long dark night of the Middle Ages had set in.

Christianity, with its Biblical traditions now came to the front, and a narrow minded literal interpretation of every syllable of these traditions was insisted on by the leaders of the church. Anything that could not be reconciled therewith was rejected with horror and scorn. The Fathers of the Church asserted that all knowledge was to be found in the Scriptures and in the traditions of the church; that in the written revelation, not only had a criterion of truth been given, but that we had been furnished with all that we were entitled to know. The scriptures therefore contained the sum and substance of all knowledge. By assuming this attitude the church set itself up as the depository and arbiter of all knowledge; and when in the reign of Constantine it became allied with the Civil power, it was ever ready and capable of compelling obedience to its decisions. Thus the Church took a course which determined its whole future career, and caused it to become a stumbling block in the intellectual advancement of Europe for more than a thousand years.

In no branch of knowledge was the desire to sweep away all the results of Greek learning as conspicuous as in astronomy. The spherical figure of the earth, which the Greeks had taught, was especially abhorrent, as were their views on the motions of the planets. Turning over the pages of the early church Fathers, one might imagine that he was reading the opinion of some Babylonian priest of a thousand years before, so similar are the ideas. But in spite of the Patristic system of the World and the efforts of the Church rulers, the ancient germ of scientific truth still lived, and during the latter centuries of the Dark Ages the idea that religion and science were of necessity opposed to each other gradually disappeared, so that by the tenth century it was not an unusual thing to find learned men recognizing that the earth might be a sphere after all; altho the final proof did not come until the voyages of Columbus, De Gama, and Magellan. The shape of the earth was thus disposed of, but the motions of the planets were a riddle of another nature and not so easily solved.

Following the Saracen invasion, Arabian translations of Aristotle began to be introduced into France from Spain. These had to be translated into Latin; and though the translations were doubtless bad, they opened up to a wondering world the treasures of Greek thought. At first the Church was hostile, but its prejudices were gradually overcome, and in 1254 special orders were issued prescribing the study of the treatises of Aristotle. The Aristotelean philosophy now became firmly entrenched in a position which it maintained for four

hundred years, until overthrown by the discoveries of Galileo. At this time came also the introduction of the ideas of Ptolemy through the text-book of Sacrobosco, which contained a short account of the Ptolemaic system.

The great revival of learning in the fifteenth century made it clear to any one interested in astronomy that, in order to build further on the foundation laid by the Alexandrian astronomers, it was necessary, first of all, to obtain a thorough knowledge of the *Almagest* of Ptolemy, for up to this time Ptolemy's ideas were known only through the indifferent translation from the Arabic. Through the labors of Purbach and his successor Regiomontanus the first Greek edition of Ptolemy was published in Europe at Basle in 1538. Five years later, in 1543, appeared the great work which was destined to mark the boundary between the Middle Ages and the Modern World,—the *De Revolutionibus Orbium Coelestium* of Copernicus. Copernicus developed mathematically an astronomical system based on the idea, that the apparent motions of the celestial bodies are for the large part caused by the motion of the earth which carries the observer with it, and hence, are not real motions at all. This he showed to be as capable of explaining the observed celestial motions as any existing variety of the traditional Ptolemaic system.

The publication of the *De Revolutionibus* appears to have been received much more quietly than might have been expected from the startling nature of its contents. But the book was in fact unintelligible except to mathematicians of considerable ability, and could not have been read at all generally. Moreover the grovelling preface inserted by the Lutheran Professor Osiander, who had been entrusted with the publication, must have done a good deal towards disarming the hostile criticism which the book must have otherwise invoked. Evidently Osiander's courage failed him; endeavoring to excuse Copernicus (and perhaps himself) he inserted the apologetic lie that the doctrine of the earth's motion was to be considered as a mere geometrical abstraction convenient for purposes of calculation, but in no sense to be considered the true state of affairs!

The Reformation put an end to the religious and intellectual solidarity of the nations, and the resulting contest between Rome and the Protestants absorbed the mental energy of Europe. Science was pushed to the background while theology was thought of first and last. But theology had gone back to the standards of the Patristic writers and again had come to mean the most literal translation of every word of Scripture; to the Protestants, of necessity, since they denied the authority of Popes and Councils; to the Roman Church, from a desire to show how unjustified had been the revolt of the Protestants. Con-

sequently neither side could be expected to be very cordial to the new doctrine which apparently opposed so many texts of Scripture. Luther, in his usual blunt way, had given his opinion of the "upstart astronomer who would assert that the earth moves and thus upset the whole science of astronomy." Even the mild and cultured Melancthon wrote to a friend that the wise rulers ought to curb such unbridled license of mind. Altho viewed at Rome with dislike from the very beginning, is was nearly seventy years before the Church authorities took serious objection to the book of Copernicus. Probably because the heliocentric theory was regarded by them as a subject for academic speculation only, and not as a matter likely to be taken seriously by any sane person, so that there was little fear of the further spread of this pernicious doctrine.

Kepler's success in taking up the problem of the planetary motions and utilizing the observations of Tycho Brahe to finish the task commenced by Copernicus is well known. The laws of planetary motion which bear his name stand as monuments to it. Thus the system of Copernicus was, as it were, brought to completion by Kepler, and all that remained was to persuade the astronomers and physicists that the motion of the earth was not only physically possible, but that it was an actual fact. The accomplishment of this task fell to the lot of Galileo.

A few months before the publication of Kepler's Commentary on Mars, the newly invented telescope was directed to the stars and in the spring of the following year (1610) Galileo published his *Sidereus Nuncius* giving the first accounts of the discoveries made with the new instrument, especially the four satellites of Jupiter and the mountains on the moon. At the end of the little book, Galileo, who for some years had advocated the Copernican system, pointed out the analogy between the earth and the other celestial bodies, and remarked that the discovery of the four moons attending Jupiter in its motion around the sun ended the difficulty of the moon alone forming an exception to the general rule, in that they moved around a planet and not the sun. Before the end of the same year the discovery of the solar spots supplied a new and very striking proof of the fallacy of the Aristotelian doctrine of the incorruptibility of things celestial, while the discovery of the phases of Venus deprived the opponents of Copernicus of a favorite weapon.

Shortly after the discovery by Galileo, the spots on the sun were discovered independently by observers in England, and at two localities in Germany. At one of the latter the discovery was made by the Jesuit, Christopher Scheiner, who later aroused the ire of Galileo by claiming the honor of priority for himself. The controversy which

followed developed into a personal quarrel, and unfortunately gained for Galileo the undying hatred of the powerful Jesuit order.

The discoveries of Galileo brought to the fore the old question of the nature of the universe as the burning question of the day, and stirred up a tremendous commotion among the learned Aristoteleans and the Church authorities. In the course of a thousand years the theologians had retreated step by step from the views laid down by the Church fathers; the Babylonian system which they had upheld had given way to the Ptolemaic; the spherical earth; and other abominations had been tolerated; but now when impious hands tried to push the earth out of its imposing place in the center of the universe, and to put spots on the face of the immaculate sun, the theologians turned fiercely to bay. Such things were not to be tolerated by those who argued that the divinely appointed way of arriving at the truth in astronomical matters was by the interpretation of Aristotle or by theological reasoning on texts of scripture. On Galileo, the champion of these vicious innovations, the whole war was at last concentrated. His discoveries overthrew the long cherished traditions of the Peripatetics, and clearly took the heliocentric theory out of the realm of hypothesis; against him the war was long and bitter; and alas, successful.

The history of the trial and condemnation of Galileo by the Inquisition is well known and would be out of place here. It is sufficient to remark that Galileo was cautioned in 1616 against upholding or teaching the Copernican doctrine because certain statements favorable to it, which had been published four years previously in the "Letters on the Solar Spots" were displeasing to the Church authorities. Nevertheless, strengthened by the courage of his convictions, Galileo continued to advocate the obnoxious doctrine, and cited most convincing arguments in favor of it in his great work, the *Dialogues on the Two Chief Systems of the World.* Unfortunately this was seized upon by the Jesuits, whose enmity he had secured through the quarrel with Scheiner, and long eager for the opportunity to settle the old score, they brought to the attention of the church authorities Galileo's disregard of their former warning. On June 22, 1633, Galileo was forced to abjure before the Inquisition; the latter decreeing against the Copernican system of the world; declaring it, "absurd, philosophically false and formally heretical; because it is expressly contrary to the Holy Scripture."

At the time of the discovery of the solar spots (1610) the Aristotelean and the Ptolemaic were the established doctrines of the day, and as such held an almost undisputed position in men's minds. The church had declared in favor of these doctrines, and since it had assumed the position of arbiter of all knowledge, only such ideas and beliefs as were in accord with Aristotle or Ptolemy could expect tolerance from

it. Aristotle was the supreme authority to whom all science had to conform. So blind had the subservience become that there were many men who refused to believe even the evidence of their own senses when this was opposed by the precepts of the Aristotelean philosophy. The discovery of the solar spots was made at the time when this philosophy was beginning to be called seriously in question. However, it was many years before Aristotle was overthrown from his high position, and it was many years more before the Church, which had defended him with encyclicals and texts from Scripture, admitted the overthrow. If these long established philosophies were shown to be erroneous, the Church's infallibility must receive a rude shock, in that it would find itself in the position of having approved and supported for a thousand years doctrines in which there was no truth. The Church, thus finding itself about to become seriously embarrassed, did not hesitate to employ whatever means were at his command to force obedience to its decisions and to prevent the spread of the new ideas, at the same time deliberately attempting to stifle the advancement of scientific learning.

Although temporarily successful in its victory over Galileo and the adherents of the new ideas, the victory of the Church was in reality an ignominious defeat, for from all sides speedily came proofs that Galileo and Copernicus were right after all, notwithstanding the Church's dictum to the contrary. Thus the Church soon found itself actually in the unenviable position of having set its authoritative stamp of approval upon a doctrine which was certainly false and impossible. Such things could only react on its influence, and in the course of time must undermine its power. Naturally, this resulted, and, the armor of infallibility once having been pierced, the Church gradually lost its position as the supreme arbiter of all knowledge.

The part in all this played by the discovery of the solar spots, which at first glance one might suppose had no connection with the matter, was by no means a small one; for the controversy over the discovery brought about the quarrel with Scheiner, in turn arousing the Jesuits, who were the prime instigators of the attack on Galileo. There seems to be little doubt of the participation of the Jesuits in this; even Galileo was aware of it and mentioned it in his letters. Further, the spots showed the falsity of the incorruptibility and immutability ideas of the heavens, which were such strong points in the Aristotelean philosophy. In addition, there was the actual evidence for the orbital revolution of the earth to be deduced from the changing paths of the spots across the solar disk. All these events combined to make the discovery of the spots a most important event in the history of the development of scientific knowledge.

While from the standpoint of the historical side of the question the discovery of the solar spots is of the highest interest, considered as a scientific achievement it can hardly be regarded as worthy of especial note. Given the telescope, the discovery must inevitably have been made sooner or later. One recalls Mark Twain's remark concerning the discovery of America, "It was wonderful to find America, but it would have been more wonderful to miss it." Or as Delambre expresses it, "S'il avait une lunette, il a pu voir les taches, il n'y a pas grand mérite à cela."

The telescope was invented in Holland in 1608, and the news of the new instrument spread rapidly over Europe. Those fortunate enough to obtain telescopes soon turned them to the examination of the heavenly bodies. Thus it naturally came about that, among other celestial objects, the spots were discovered independently at several places by different observers at about the same time.

The earliest of these was Galileo. It will be shown that he most probably saw sun-spots with a telescope for the first time at Padua during the summer of the year 1610. It seems that Galileo made no definite announcement of the discovery at that time, at least there is no evidence of any such announcement, but he showed the spots to his friends at Padua, probably as a matter of curiosity. The epoch-making discoveries of the satellites of Jupiter, the phases of Venus, and the triple bodied Saturn were announced in the same year. These discoveries excited an intense interest throughout Italy, and in order to enlighten the incredulous, Galileo journeyed to Rome in the spring of the following year and publicly exhibited the spots and other "celestial novelties" in the Quirinal Gardens of the Carninal Bandini.

The second individual to observe the solar spots with the telescope was the English mathematician, Thomas Harriot. Harriot's first observation was made on the 8th of December 1610 (O.S.).

It is certain that the first publication in Europe giving an account of the spots was by Johann Fabricius, the son of David Fabricius. Johann first saw the spots with the telescope at Osteel in East Friesland on the 27th of February 1611 (O.S.).

The fourth individual who asserted that he had observed the spots independently was Christopher Scheiner, the German Jesuit and Professor of Science in the University of Ingolstadt. Signed with the assumed name of "Apelles latens post tabulam," Scheiner sent an account of his observations in a series of three letters to Mark Welser,* the Mayor or Chief Magistrate of Augsburg. These letters were printed and a copy of the publication was forwarded by Welser to Galileo.

* Born June 20, 1558, died January 23, 1614.

of whose observations Welser had already heard, requesting an opinion on the subject. Galileo replied with a similar series of three letters addressed to Welser. In the first Apelles' letter, which is dated November 12, 1611, Scheiner asserts that he first observed the sun-spots some seven or eight months previously. This statement would carry his first observations back to March or April of that year; at approximately the same time that Galileo was exhibiting the spots at the Bandini Gardens in Rome.

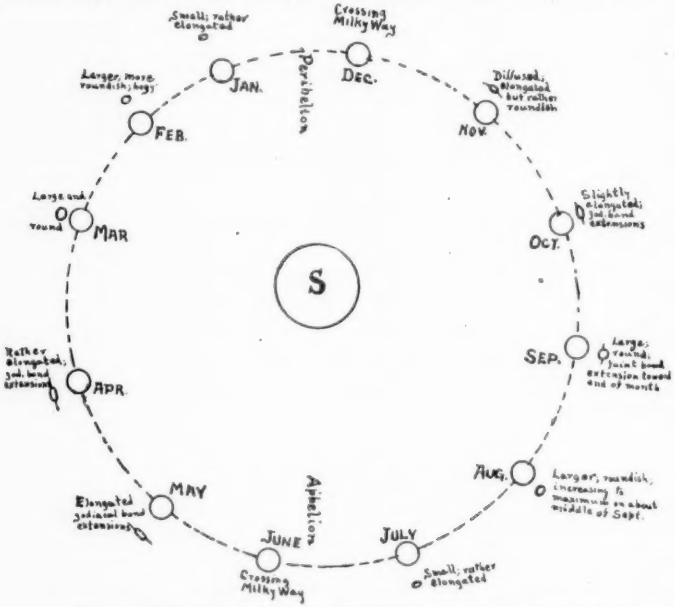
(*To be continued.*)

## GEGENSCHEIN CONFIGURATIONS.

Rev. W. E. GLANVILLE, Ph. D.

Professor Barnard's valuable notes of gegenschein observations made between 1891 and 1899 and reported in POPULAR ASTRONOMY, 1899, April, are the basis of the accompanying diagram. An inspection of it shows that the size and shape of the gegenschein vary periodically in the course of the year; and that at certain times, also periodic, extensions of the gegenschein illumination are noted E and W along the ecliptic, similar to the zodiacal light. The gegenschein moves east along the ecliptic at the rate of about 1° a day. In December and June it crosses the Milky Way and is not then discernible. By reference to the diagram it is seen that in January the gegenschein appears small and slightly elongated. The same notation applies to July, Similarly, February and August correspond, as do March and September; April and October; May and November. Manifestly this annual recurrence of varying size and shape cannot be the result of mere chance and one is naturally disposed to press the question: How may it be accounted for? It has been suggested that the cause may be sought in the configuration of the gegenschein with respect to the earth and the sun each month. The earth is not a perfect sphere but an oblate spheroid. Its axis being inclined 23½° to the ecliptic, with the North Pole pointed away from the sun at the Winter Solstice and maintaining this inclination parallel to itself throughout the year, it follows that the perimeter as presented to the sun along the ecliptic is not uniformly circular. For instance, the rotundity of the earth as presented to the sun in December and June is not precisely the same as that presented to the sun in March and September and there are minute variations during the intervening months. Assuming that the

gegenschein is caused by sunlight refracted from the earth's perimeter it is urged that the shape of the gegenschein will vary seasonally on account of the greater or less rotundity of the earth as presented on the ecliptic month by month. This may enter as a factor—but only a minor factor—into the solution of the problem. It is certainly not sufficient to account for the marked change in size as, e. g., between July and September. A more plausible solution is offered as follows:




VARYING SIZE AND SHAPE OF THE GEGENSCHEIN DURING THE YEAR.

Referring again to the diagram it is plain that the gegenschein illumination is at maximum in September. Then it declines in size until in January it is small, after which it increases to maximum in March; thence it declines until in July it is again small; thereafter it increases to maximum again in September. It is unfortunate that no observations are possible in December and June owing to the gegenschein crossing the Milky Way during those months. Arguing from the decline to minimum and the increase to maximum I would predicate that were observations possible in December and June it would be found that *during these months the gegenschein reaches its minimum illumination.* This, I venture to submit, is a soberly reasonable inference. So that we have maximum in September, minimum in December, maximum in March, minimum in June—two maxima and two minima in each year. Advocates for the Light Pressure theory as accounting for zodiacal light

and gegenschein phenomena may here inform us that these periodic maxima and minima of gegenschein illumination support their theory, on the ground that during March and September the earth is exposed to the more active zones of solar activity, because the sun's axis is inclined 83° to the ecliptic, with the North Pole pointing towards the place occupied by the earth in September. We reply to this contention by asking them to account for the E and W zodiacal band extensions witnessed in October and November and in April and May; and also to account for the regularly varying *shape* as well as size of the gegenschein in the course of the year. Rather are we disposed to attribute the periodic variations in size of the gegenschein to rythmically *varying distance from the earth. At maximum we consider the gegenschein to be at perigee; at minimum to be at apogee.* The E and W zodiacal band trails of the illumination demonstrate the *continuous extension of the zodiacal band material along the ecliptic.* Connecting this with the zodiacal light appearances on the E and W horizons which extend sometimes 90° from the sun as seen at or near sea level and even clear across the sky, the gegenschein and zodiacal light sometimes merging, as seen from altitudes of 1½ to 2 miles above sea level, we have confirmatory evidence of the Earth Ring theory of the Zodiacal Light which I have discussed in former papers. The marked difference in size between the gegenschein illumination at maximum and minimum respectively may be regarded as indicating an ellipse of rather high eccentricity, subject perhaps to lunar perturbations, for the fact of the Moon Zodiacal Light shows that the zodiacal band material—whatever its nature is—is intermediate between the moon and the earth.

NOTE:—A point I have nowhere seen investigated in connection with studies of the gegenschein and zodiacal light is *the bearing of refraction* on these phenomena. The denser the atmospheric strata the more intense and concentrated is the refraction of sunlight from the earth's perimeter. In the higher and more rarified strata refraction is proportionally less and consequently refracted light reflected from an object on which it falls is correspondingly more dispersed. And not only the density of the atmosphere (which is greatest at sea level) but also the *temperature* of the atmosphere affects the intensity of refraction. From our north temperate latitudes we view the ecliptic at night, during most of the year, through the densest strata of the atmosphere. In the tropics the conditions are different even at sea level when the question of temperature is considered. There, particularly at high elevations, the zodiacal light shows up more conspicuously.

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# REPORT ON MARS, No. 13.

WILLIAM H. PICKERING.

## Latitudes and Longitudes.

An investigation has been made of the best method of determining latitudes and longitudes on Mars. While it is not yet complete, a preliminary statement may be made in time for this opposition. The best method of determining longitudes does not require a micrometer, but only a position circle. The thread is set parallel to the axis of the planet in accordance with the ephemeris, and the time recorded when the given point and the center of the northern polar cap are equally distant from the thread. This method has given excellent results in the hands of Dr. Lowell, and while there are theoretical objections to it, yet in practice it has proved very satisfactory. A correction must be made for the phase, and also for the slight eccentricity of the cap, the center of which according to Dr. Lowell in 1903 lay in longitude 195°, latitude 89°.4 (Bulletin No. 18).

The best method of determining latitudes is by means of the micrometer, a measure being made just before and again just after the point reaches the central meridian. If a micrometer is not available, very nearly as good results may be obtained by a series of drawings. Since it is only necessary to locate the given point on the disk, this observation need not require very much time. These methods of measurement can be used to best advantage near the time of opposition. While at other times the correction for phase is larger, this may always be made by graphical methods, making the measures on a large scale drawing, constructed from the ephemeris.

When it is desired to locate points not seen to transit the central meridian, the micrometer method is the best. Here too, much computation may be saved by graphical methods which are available for this purpose, since no high degree of accuracy is possible in any case on so small a disk as the planet presents. When a point is sharply defined and well seen, we should be able to locate its position within rather less than 1°, that is to within less than forty miles, or sixty kilometers. Orthographic projections of the sphere eight inches in

diameter may now be purchased of the J. L. Hammett Co. of New York and Boston, and the measures plotted directly on them, a correction being made later for the inclination in latitude of the line of sight.

Besides their obvious purpose of map making, there are two other reasons why determinations of position should be secured. First to settle the period of rotation of the planet, which controls future computations of the ephemeris, and second to determine the extent and direction of the local shift of the various markings upon the surface. While the shift is in most cases so slow as to be noticeable only from one presentation to another, yet in the case of the polar marshes, the Syrtis marsh, and the polar bands, the change may be watched occurring from night to night, and sometimes even from hour to hour. The gradual shift is most marked among the dark markings of the planet in the southern hemisphere, but it is of more interest among the lakes and canals.

To determine the period of rotation, observations of the following points, which seem to be fairly stationary on the disk, are recommended: The promontories of Hamonis and Edom, especially the latter, and the bay where Euphrates enters Sabaeus. The first two are not marked on Schiaparelli's map given in Report No. 1, but may be described as the promontories following the Syrtis Major and preceding the forked bay of Sabaeus. Phoenices and Titanum at the northern extremity of Sirenum also appear to be excellent points, although the latter was suspected of some motion during the last opposition. The center of Solis Lacus according to most observers is fairly stationary. These points have all been widely observed in the past.

Points which clearly shift through a considerable range are Oxia Palus at the northern extremity of Margaritifer, the junction of Nectar and Aurorae, and the Syrtis minor. Several of the lakes appear to shift more or less; Siloe, (known also as Dirce,) Juventae Fons, Propontis, Trivium Charontis and Ismenius. The extent of the maximum shift from the mean ranges in general from 3° to 5°, 120 to 200 miles. The mean latitudes and longitudes of these various objects are given in Table I. The mean longitudes of Aryn on the present ephemeris is 359°.2. Its latitude ranges from +6°.8 to −5°.6, mean value +0°.1. Since its axis is usually inclined about 15° to the meridian, its longitude would obviously vary appreciably from this cause alone, if for no other. In point of fact Lau's observations make its longitude 355°.9 when reduced to a common standard with the other observers, while those of Wislicenus and of Lowell in 1894, similarly reduced, make it 0°.1, total range 4°.2.

TABLE I.

LATITUDES AND LONGITUDES OF CERTAIN POINTS.

| | | |
|---|---|---|
| **For Rotation** | | |
| Solis Lacus, center | −26°.9 | 86°.0 |
| Phoenicis | −13.6 | 107.5 |
| Titanum | −18.9 | 169.6 |
| Hammonis | −11.2 | 315.5 |
| Sabaeus, Euphrates | − 6.5 | 337.7 |
| Edom | − 7.4 | 352.3 |
| **For Shift** | | |
| Margaritifer (Oxia) | + 8°.1 | 19°.0 |
| Aurorae Nectar | −26.1 | 64.3 |
| Syrtis Minor | − 6.5 | 255.6 |
| **Lakes for Shift** | | |
| Siloe | +34°.0 | 3°.9 |
| Juventae Fons | − 1.0 | 64.0 |
| Propontis | +49.0 | 175.0 |
| Trivium Charontis | +17.2 | 198.9 |
| Ismenius | +42.1 | 335.7 |

THE POLAR CAP.

There seems to be considerable variation in the date assigned by different observers for the maximum size of the northern polar cap. That it should differ somewhat in different years we may well believe, but that the difference should be as great as the various observers indicate appears incredible. It is an observation easily made, by simply measuring a series of carefully executed drawings, and then dividing the diameter of the snow cap by that of the planet. The accuracy which can be secured by this means is much greater than one might naturally expect. Thus a comparison of observations made at the same time by Professor Douglass and the writer showed that the average deviation between the results was 2°.2, or 85 miles (136 km). This amounts to one fiftieth of the diameter of the planet, which corresponded to about 0″.3 at that time (Report No. 3).

In 1882 the maximum size was reached according to Schiaparelli at more than one month after the vernal equinox (Flammarion I, 460). This would correspond to ⊙ = 13°.8 + or to M. D. March 29 +. The latitude reached was 67°.5. Turning to Lowell's "Mars as the Abode of Life", p. 268, we find two determinations of ⊙ for the maximum size, 8° in 1897, and 273° in 1907. The latter was not a favorable year for the

observation. These longitudes would correspond to the Martian dates March 17 and December 16. The mean latitudes reached were 51°.5 and 45°.0. In the Report of the Mars Section of the B. A. A. for 1893 are given two curves indicating that the maximum in 1898-9 and 1900-1 came as much as 180 days before the summer solstice. This would correspond to ☉ 9°.5 or M.D. March 20. There are however only half a dozen observations extending back as far even as 200 days in the first curve, that is to the equinox, ☉ 0°.0, and only one preceding the supposed maximum in the second. The dates are therefore very uncertain, giving in fact only maximum values of ☉. The mean latitudes reached are 64° and 64°.5. The dates thus range from December 16 to later than March 29, and the latitudes from 45° to 67°.5. Regarding Dr. Lowell's two observations which differ widely from one another, no details are given, the other three determinations are obviously unsatisfactory.

It might appear at first sight that neither 1913 nor 1915 were particularly favorable years in which to determine these two quantities, since in both cases the date of maximum size came appreciably earlier than the date of opposition. On examining our results however we found that only one recent opposition, that of 1911, would have been more favorable, and that there would be no further opportunity to make a satisfactory determination for a number of years.

In Figure 1 are shown all the observations that were obtained in Jamaica during the opposition of 1913-4 and all of those obtained in 1915 through November 30. The former are indicated by dots, the latter by small circles. The ordinates represent degrees of Martian latitude, and the abscissas degrees of solar longitude ☉. These latter are given beneath the curves, and below them the corresponding Martian dates. At the top are given terrestrial dates, the upper row those for 1913-4, the lower those for 1915-6. The two short vertical lines indicate the dates of opposition, the left hand one that of 1914, the other that of the present year. The smooth curves show the mean positions of the snow line in the two Martian years, and indicate, as already pointed out in Report No. **12**, that the present year was the colder, or at all events the more snowy upon Mars. On comparing the drawings of the two years this difference is quite noticeable.

On carefully reading over our own notes, we found that on only one occasion during each of the two years considered, was it at all likely that prior to ☉ 350° it was the snow itself that was observed. On all the other dates the bright area was described either as cloud, as yellow, or as greenish. In other words as long as the polar cap was increasing in size, it seems to have been concealed by something,—undoubtedly cloud. As soon as this cloud cleared away, at about ☉

350°, the brilliant area appeared, and was invariably described as white. Immediately after this it began to diminish in size.

A large bright cloud visible in the Martian December in 1907 may well have been mistaken by Lowell for snow, while the lack of brilliancy of the polar cap in 1898 and 1900 may have led the British observers to doubt if what they saw during their earlier observations was really the cap at all. Lowell's result in 1897 is probably more nearly correct. The four crosses indicate the positions of the maximum size as determined by Schiaparelli, the British observers, and Lowell in 1897. The determination by the latter in 1907, ⊙ 273°, would not fall upon the sheet. It will be remembered that Schiaparelli gives merely a minimum longitude.

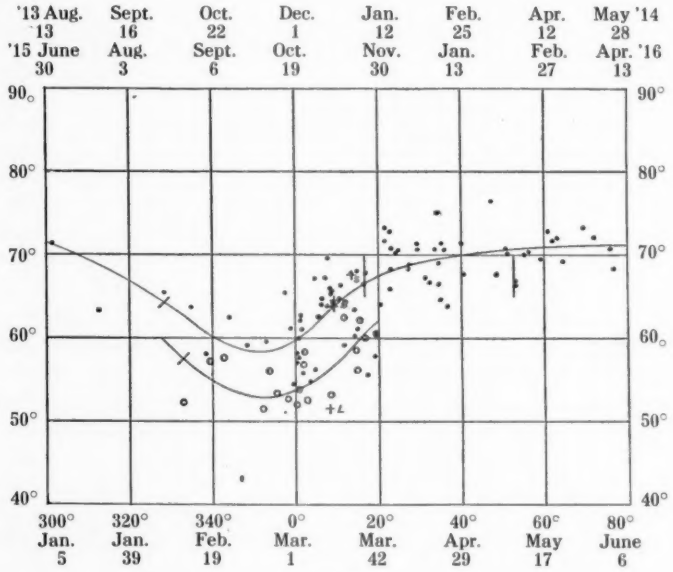


FIGURE 1.

The dark band surrounding the polar cap, and due to its melting, was first detected in 1913 at ⊙ 328°.2, M. D. January 53, and in 1915 at ⊙ 332°.9, M. D. February 5. These dates are indicated by short diagonal lines. This band and the study of the curves leads us to believe that the size of the cloud could not in general have been very different from the size of the snow beneath it, except in the case of the observation at abscissa 345°, when the cloudy area was unusually extended. It gives us at all events a southern limit in latitude. Whether when we observed it, during the Martian daytime, snow was actually falling, or

cloud and mist were merely rising from the melting snow that had fallen during the previous night, we cannot tell, but observations made later in the Martian year lead us to believe that at that time at least most of the precipitation occurred at night.

Returning to the Figure, at the time of opposition a deviation of 5° of latitude from the line giving the mean diameter of the snow cap, would represent an angular deviation of 0″.6, but at abscissas 320° and 60° in 1913-4 the angular deviation would be reduced to about 0″.3. The later deviations however seem to be no greater than those recorded near opposition. While as a rule they do not exceed 5°, we find a series of large deviations in 1913-4 occurring at fairly regular intervals at about solar longitudes 345°, 0°, 17°, 36°, and 53°, at which times the cap seemed to be unusually large. The mean longitude of the central meridian at the time that these observations were made was 357° ± 30°.

This cannot indicate an elliptical shape of the spot, since in that case larger diameters should also be found at 180° from this position, or in longitude 177°, which is not the case. The most probable explanation seems to be that the cap was really larger in this position, owing to its greater extension towards the sunrise or sunset limb. It could hardly be the latter, but clouds or snow might persist for a time after sunrise in certain localities under suitable conditions, and thus apparently increase the size of the cap on that side. Measuring 90° towards the sunrise limb from longitude 357° brings us to longitude 87° which lies slightly to the west of the following or western border of the Acidalium marsh, the largest of the four marshes surrounding the polar cap, and the only one that was conspicuous after February. This is exactly where we should expect to find cloud at sunrise, according to Reports Nos. **3** and **4**, and also according to the observations already made at this opposition.

In Report No. **4** we noticed the slow increase in longitude of the twin polar bays, as they gradually shifted to the west, as the result of the daily evaporation and nightly deposition of their moisture, combined with its southerly motion toward the equator. Nine measures of favorable drawings of the southern end of the following side of Acidalium, made during the same period, give its longitude as follows:— Nov. 26 36°, Dec. 1 42°, Dec. 4 40°, Jan. 5 41°, Feb. 8 47°, Feb. 10 45°, Feb. 12 50°, Mar. 20 60°, Apr. 21 60° (?) The same gradual change of position it will be seen occurs.

The inclination of the planet's axis to its orbit is determined by observations of the position angle of its polar caps. If the northern cap is more extended towards the sunrise than towards the sunset limb in certain longitudes, owing to the deposition of snow or cloud, it is clear

that a correction not wholly negligible, due to this cause, should be taken into consideration in future determinations of the inclination of the axis.

Using the smooth curves of the Figure as average values, we find that the snowy season reached its maximum in both years shortly after abscissa ⊙ 350°, corresponding to the Martian dates of February 39 and 43, and that in latitude 60° the snow persisted from February 20 to March 2 in the former opposition, and from January 53 until March 32 in the present one. These seem rather short seasons to us for so high a latitude, when counted by months, although the former lasted for 38 days and the latter 91. This is due without doubt to the small amount of water on the planet. The lowest latitudes reached were 58° and 53°, giving a difference of 185 miles (295 km).

### Observations in November.

On November 4, M. D. March 17, a drawing was made with the central meridian ω in longitude 112°. The polar cap was white and brilliant, there was no cloud on the terminator, but a very slight haze at the south pole, and the southern limb was the same brightness as the centre of the disk, which shone clear and red,—No. 9 on the color scale with tungsten, and No. 14 with the standard blue. There was therefore no cloud on the disk. Nevertheless all the detail, save the polar cap and the grey band to the south of it, was excessively faint. The greys and greens had as yet in no way developed, all the water apparently being at first deflected to other points of the planet, leaving the surface red and barren. This was true also at the last opposition, this longitude being the last to develop at that time. The region about Solis Lacus, that is Thaumasia and the Solis itself were a light uniform grey. Next in visibility came a light bay pointing to the north, and located some 20° to the north of Nodus Gordii and slightly to the west of it, in longitude 131°, latitude +25°. This same marking, although rather more distinct at that time, had been recognized in 1913, M. D. December 54. As far as the writer is aware it had never been seen before; nor since that date, until this year. The darkened area was of perhaps double the size of Solis Lacus, but exceedingly faint. Portions of Pyriphlegethon and Gigas were suspected. In 1913 the Solis was first seen December 25, M. D. March 25, and within five days had developed in great detail.

November 13, ω 29°, M.D. March 25; although the seeing was fair, and the Acidalium marsh extended nearly 0.4 way across the disk, the southern maria were exceedingly faint, their northern boundary extending east and west in a straight line without detail and without darkening. They were indeed only detected by their pale green

color. The marsh showed slight polarization when examined with a double image prism and quartz plate, indicating a surface, liquid in part.

November 17, ω 357°, M. D. March 30. Sabaeus showed the first signs of development as a slight projection towards the north, and darker than anything save the Acidalium marsh. The southern maria were green, the northern grey. The most unexpected feature was the persistence of the north and south band, which starting from slightly to the east of the marsh stretched straight across to Sabaeus. Its western border was hazy, and its breadth was about 300 miles. It lay in the region between Gehon and Indus. The next day it had become markedly narrower. The brightness of the deserts was 7 and the band 6. Perhaps the most interesting thing about it was a slight tendency towards the double effect. Conditions were unfavorable however, and no conclusion was reached.

If we compare Figure 2 with the four figures given in Report No. 11, we shall be struck with the different development in different regions of the planet. Thus, while the Martian date is later in the present Figure, and the Acidalium marsh more developed than in any of the others, save Figure 3, yet Sabaeus itself is no further advanced than in Figure 1. As compared with Figure 2 the marsh in the present Figure is more developed, and Sabaeus less so. As compared with

FIG. 2
1915 November 17
Martian Date March 30
357° 7″.8

Figure 3, Sabaeus is in a most undeveloped condition, although the Martian date is four weeks later. Compare also with the colored Figure 2, issued with the Index, which was drawn but six days later in the Martian year than the present figure. Sabaeus was still connected with the dark band when last seen November 19, and the projection of the Forked Bay had become slightly more pronounced. The southern boundary had also appeared, so it is quite possible that its development will take place quite rapidly before we next observe it in December. In the mean time it is hoped that some of our Associates

in Australia or Asia may watch and record the gradual process of its development in that case, and send us notes and drawings of the same. In the mean time we may ask (*a*) will the north and south band continue until Sabaeus is as far advanced as it was when the band disappeared in 1913, Figure 2, or (*b*) will the band cease immediately, now that the polar cap has become equally reduced in size? The two short lines in the Figure indicate the position-angle of the poles. Obviously there is no trace of Aryn, so far in the Martian year.

In Report No. **12**, Table III, line 8, it was assumed that the north and south band had disappeared on the Martian date of February 53. It is now shown to have been clearly visible on March 32, or 35 days later, thus removing this phenomenon from the list of those which came early this year, and adding it to those which came late. On comparing the phenomena of these two oppositions we see that besides the changes in place occurring on Mars, we have also changes in time. The former are well illustrated by the unexpected appearance of Thoth in 1911 and 1913, as illustrated in Report No. **7**, Plate XXXII, and also by the development of the twin polar bays Propontis and Castorius, mapped in Report No. **4**,—where a swamp 1200 miles in length developed, which in previous years had appeared only as a small and inconspicuous lake, barely 100 miles in diameter. It is much as if Lake Ontario should suddenly develop into a swamp reaching from New York to Omaha, and as broad as the lake is long.

It is possible that some day we may be able to predict these developments in advance, but at present we see not the slightest chance of being able to do so, and can only record them with all their attendant phenomena as fully as possible, to furnish data to be used by the astronomers who follow us. With regard to the changes in time however, we are in a somewhat different position. Comparing the present and the past oppositions, we find that in both cases the snow cap reached its maximum development at about the same date, but that at the present opposition the snow extended nearly 200 miles or five degrees farther south than it did at the other. If in the case of our own planet the isotherm of melting snow should one year extend 200 miles farther south than the next, that one year for instance it did not extend beyond New York, and the next should reach as far as Richmond, we should not be surprised to find that vegetation was a few weeks delayed in consequence in its development. With the longer year upon Mars, the delay might be still greater than with us.

What we actually find by Report No. **12**, Table III, is that while the Acidalium marsh, situated 200 miles farther south than before, at the edge of the snow, developed this year four weeks earlier than in 1913, that the Syrtis marsh and vegetation, far to the south of Acida-

lium, developed from four to nine weeks later. With such brief and limited observations we cannot of course claim to have demonstrated a connection between the phenomena considered, but we can at least say that a connection between them seems plausible, and that a later development in a colder year is what we should naturally expect. It will certainly be of interest at the next opposition to see if these results are in any way confirmed. It would at least suggest that in the future we might predict approximately the week of appearance of any given marking by the size of the snow cap. It will also further interest us if a colder winter on Mars, as indicated by our observations of the past September, October, and November should be followed by a colder or more snowy winter on our own planet.

Another point which the writer wishes to make clear is that in order to determine the exact time at which the various features on Mars develop, it is most important to secure continuous observations of them from the earth. These can only be obtained by means of a series of stations located all around our planet, with their reports sent in to one central authority. This is the main object of the organization known as the Associated Observers of Mars, and it is greatly to be hoped that some of its members located on the other side of our globe will be willing and able to secure the early morning observations which are necessary during the period two or three months preceding the date of each opposition.

On November 18 the duplication of the north and south band was again suspected, but the continuance of unfavorable conditions, mainly wind, again rendered its confirmation impossible. A dark spot visible the previous night in the region of the Forked Bay was now invisible. The continuous canal named in different sections Protonilus and Deuteronilus had clearly developed. The cloud which usually follows the Acidalium marsh was well seen, though the marsh itself was invisible. Since the latter was within 60° of the central meridian, it was presumably at this time covered by the cloud. The polar band was invisible, though well seen the previous night, see Figure 2. Mars was 0.1 magnitude brighter than Procyon, but still 0.6 fainter than Saturn.

November 19, $\omega$ 315°, M. D. March 32. The cloud at the south pole was white in color, not yellow, but was clearly less brilliant than the snow. A minute cloud was noticed bounding the snow cap on the south near longitude 0°. It was within perhaps two hours of the central meridian. Ismenius Lacus had developed, but was still a delicate object. The southern boundary of Sabaeus was seen for the first time. It certainly was not visible November 17 or 18, although on the latter date the Sabaeus region was drawn as slightly darker than that to the south of it, showing gradual development.

The writer confirms the result of other observers that when the seeing is excellent, looking through a piece of very light yellow glass slightly improves the definition. On approaching the terminator the Syrtis disappeared at a distance of 40° from the central meridian. The duplication of the north and south band was suspected for the third time, and again without reaching any conclusion. Seeing 9.

The position angle of the band just before it crossed the central meridian was found to be 9°, i.e. 9° west of north as measured on the planet. In August and September it was inclined about as much to the east of north. It will probably finally develop into the canal Gehon. The first color sketch was made this year, ω 341°. The green of the Sabaeus region was very faint, apparently fainter than last year at this Martian date.

November 21, M. D. March 34, ω 293°. The difference in brightness of the desert regions on either side of the Syrtis is very striking, that preceding it, between it and Thoth, being only 4, while following the Syrtis, that is to the west of it, it is 6. The south pole was 8, and of a greyish yellow. The Syrtis marsh was grey, brightness 2. The southern maria like those at the north were grey. Libya was the greenest region, but even there the color was not marked. The equatorial limb was only slightly brighter than the center, indicating that the disk was free from cloud. No clouds were detected on either the limb or terminator. The south pole was recorded as of the same color as the snow, though less brilliant, 9.

The scale of Canals described in Report No. 7 was first tried with Mars in June 1914, but the planet was then so remote that the results were unreliable. It was next tried this year November 19, but with Scale J, drawn with a number 3 pencil. This scale matched Sabaeus and the Syrtis marsh very well, but was much too dark for the canals. The results were unsatisfactory, but the necessity of matching the canals exactly in density was made very obvious. The color and brightness of the paper were found to match the surface of the planet satisfactorily when a magnification of 660 was employed. With this power one millimeter on the scale corresponds to 0″.065. Scale E drawn with a number 4 pencil was now substituted for J, and the following results obtained, ω 315°, seeing 7, Syrtis marsh measured east and west through middle 0″.39, Deuteronilus 0″.32, north and south band 0″.13, Sabaeus 0″.39. Reducing these for the inclination of the surface at the time of observation, gives us the following breadths:— Syrtis 233 miles (374 km), Deuteronilus 194 miles (310 km), north and south band 95 miles (152 km), and Sabaeus 250 miles (400 km). Measurements made from a drawing on November 19 give us for the Syrtis

272 miles, deviation + 39, for Deuteronilus 182 miles, deviation −12, for the north and south band 58 miles, deviation − 37 and for Sabaeus 317 miles, deviation + 67. Considering the remoteness of the planet at the present time, and the consequent fact that 52 miles equal 0″.1, these deviations are no greater than we might naturally expect. While for these comparatively wide canals it is believed that the scale gives more accurate results than the drawing, it is thought that for still narrower canals the scale will give very much more accurate results. These observations indicate that there is no large systematic error introduced by the scale readings, at least as far as the drawings can serve as a standard of comparison. Later, when more and finer canals are visible, we shall test the method for accidental errors.

November 23, ω 308°, M.D. March 36. The Syrtis marsh was but little darker than the region surrounding it, and it is doubtful if it now contained much water. Heavy clouds were seen on the terminator to the south of the Syrtis. A very fine line of cloud bounding Protonilus on the north and crossing the central meridian was detected. Clouds seem to favor the northern and following sides of dark markings at all seasons of the year. An east and west rift in the snow cap was suspected. Orontes glimpsed, but still doubtful. There was no trace of green in the Syrtis, although the seeing was 11. A little was suspected near Libya.

November 26, M.D. March 39. At 15h 20m when about 30° west of the central meridian Casius was very marked and dark; two hours later when central is seemed much less so. In this longitude the southern maria are clearly greenish. A minute white cloud was detected near the central meridian half-way between the Syrtis and Thoth; the next night it could not be found.

November 27, ω 242°, M. D. March 40. Polarization suspected in the canal Nilosyrtis, but not seen anywhere else. A white area was noted near Novissima Thyle in latitude −70°, and measuring about 1000 miles across, which was as white and as brilliant as the northern polar cap. It was surrounded by a fainter belt of cloud. It seems possible that it was the beginning of the southern snow cap, from a portion of which the clouds had temporarily cleared. Seven canals were visible this evening.

November 29 a bright cloud was seen on the northern limb extending half-way to the central meridian. A large marsh, Propontis, was visible near the terminator.

TABLE II.

DATA OF THE OBSERVATIONS.

| No. | 1915 | ⊙ | M. D. | Long. | Lat. | Sun | Diam. | Seeing |
|---|---|---|---|---|---|---|---|---|
| | | ° | | ° | ° | ° | ″ | |
| 22 | Nov. 4 | 8.2 | Mar. 17 | 112 | +17 | +3 | 7.2 | 10 |
| 23 | " 13 | 12.0 | " 25 | 29 | 18 | 5 | 7.7 | 8 |
| 24 | " 17 | 14.4 | " 30 | 357 | 19 | 6 | 7.8 | 7 |
| 25 | " 18 | 14.8 | " 31 | 329 | " | " | 7.9 | 6 |
| 26 | " 19 | 15.4 | " 32 | 315 | " | " | 8.0 | 10 |
| 27 | " " | " | " " | 341 | " | " | " | 8 |
| 28 | " 21 | 16.4 | " 34 | 293 | " | 7 | 8.1 | 8 |
| 29 | " 23 | 17.3 | " 36 | 308 | " | " | 8.2 | 11 |
| 30 | " 27 | 19.2 | " 40 | 242 | " | 8 | 8.5 | 7 |

The following lakes and canals were seen:—

Nov. 4 **C** Pyriphlegethon, Gigas, Eurotas.

Nov. 13 **A** Tanais.

Nov. 17 **A** Callirrhoe.

Nov. 18 **F** Protonilus, Deuteronilus.

Nov. 19 **FA** Nilosyrtis, Protonilus, Deuteronilus, Gehon. Ismenius Lacus.

Nov. 21 **F** Nilosyrtis, Thoth, Nepenthes, Protonilus. Ismenius Lacus.

Nov. 23 **F** Nilosyrtis, Protonilus, Deuteronilus, Orontes (?) Ismenius Lacus.

Nov. 27 **E** Nilosyrtis, Casius (formerly referred to as Boreosyrtis), Thoth, Nepenthes, Cerberus, Eunostos, Alcyonius.

Communications have been received from Messrs. McEwen and Lau, of the Associated Observers. Both succeeded in seeing the north and south band. This is most important as corroborative evidence of a striking phenomenon, first seen at its maximum dimensions in 1913 and 1915, and first seen upon a smaller scale in 1911, at the observatory of M. Jarry Desloges (Observations **3**, Plates 7 to 10). So striking and conspicuous indeed is the phenomenon when at its maximum, that we can scarcely doubt that it is a new development upon the planet. The very fact that it was visible to Messrs. McEwen and Lau with only 5-inch and 4-inch telescopes, when its breadth and density were well past their maximum, and the band had already become comparatively inconspicuous, indicates that had it appeared of its full size and density at earlier oppositions, it would certainly have been discovered by some one. If a phenomenon of this size, covering over a million square miles of surface upon the planet, is really a new development, it is unnecessary to call further attention to its importance.

On September 27 Mr. McEwen writes "A fainter shading extended southwards from Lacus Niliacus to about the position of Margaritifer Sinus. This shading probably included Indus and Hydaspes....It was doubtful if Margaritifer Sinus was visible, although Indus and Hydaspes were clearly seen, the latter as a faint band lying in a N and S direction." This is where we saw the band on October 9. On September 28 he writes "Indus and Hydaspes presented the same appearance as yesterday." September 30, "Indus broad and diffused, starting from Mare Acidalium. It was faintest at the N end; towards the S end at Margaritifer Sinus the tint deepened, making the E boundary sharp and the W somewhat softer." If we examine Figure 2 we shall see that his description of the difference between the eastern and western sides is fully confirmed, although by November the band had gradually shifted its position in an easterly direction, so as now to connect the eastern side of the Acidalium marsh and the Forked Bay of Sabaeus.

Professor Lau sent a drawing made November 9, which is practically identical with Figure 2, except that by that date the northern end of the band had not advanced quite so far, and consequently joined the southern end of the marsh to the Forked Bay. The band presents the same characteristics of the sharp eastern and hazy western borders.

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### KING WINTER'S GALAXY.

Resplendent 'mid bespangled skies.
King Winter's galaxy is seen,
Where Pleiades wink tiny eyes
And Taurus in red fury lies,
And bright Capella reigns—a Queen!

Where like some background in the sky
Yon Jacob's Ladder gleams between
Orion's gems and Gemini,
When Canis Minor's sun near by
And Sirius adorn the scene.

Supernal—silent—and sublime!
The same today as they have been
Since Nature woke terrestr'al time
Or pyramid was in its prime,
Or Earth with life's first dawn was green.

CHARLES NEVERS HOLMES.

## ASTRONOMICAL PHENOMENA IN 1916.

### ECLIPSES.

In the year 1915 there were only two eclipses. In 1916 there will be five eclipses, three of the sun and two of the moon. For the figures and detailed description of these eclipses the reader is referred to the paper "The Eclipses of 1916", beginning on page 1 of this number.

### THE PLANETS.

The accompanying charts, Figures 1 and 2, will be useful in following the courses of the planets for the year. To any one who has a little acquaintance with the appearance of the sky, the brightest of the planets, Venus and Jupiter, will be easy of identification whenever they appear. For those planets which more nearly resemble stars and for those not visible to the naked eye, it is necessary to have some means of knowing their position in the sky. Since they will all be lost in the rays of the sun, at certain periods of the year it is desirable to know when and where their reappearance may be expected. The charts do not show the positions of the sun although they do show its path as the heavy line, the ecliptic, which intersects the equator at the extremity of each diagram. The position of the sun along this path can be found with accuracy sufficient for the purposes of the charts by remembering that the sun moves from $0^h$ to $24^h$ at the rate of two hours a month, beginning on March 22. By locating the sun in this way it is possible for any one to decide whether or not a given planet is to be seen as a given date.

*Mercury* completes about four revolutions about the sun in the course of the year. Since its orbit is relatively small it is always in the same part of the sky as the sun. It therefore, as seen from the earth, partakes of the apparent motion of the sun toward the east. At three periods in the year however its motion coupled with that of the earth is such as to make it appear to move westward in the sky or, as it is called, to have retrograde motion. It begins the year in Sagittarius, moves into Capricornus and describes a loop there in February and March, then proceeds eastward until June when it moves retrograde for a short period in Taurus, then proceeds eastward again until October, when it moves westward for a short time in Virgo, then turns and moves eastward again and ends the year near the eastern boundary of Sagittarius, having completed a little more than one circuit around the sky. This planet is visible only at very limited periods. On and near the following dates it will be visible in the east just before sunrise: March 1, June 29, October 20; on and near the following dates, on the western horizon just after sunset: January 20, May 12, September 9.

*Venus* will start its course for the year in Capricornus. It will move continuously eastward until June when it will turn and move westward in Gemini during June and July. About August 1 it will again start eastward and continue in that direction for the rest of the year. Because of its retrograde motion it will end the year in Scorpio, about four hours east of its starting point.

This planet will begin the year as the bright evening star, low in the west at sunset. It will rise higher and higher in the evening sky until April 23, when it reaches a point of greatest elongation east of the sun. It then will be found lower

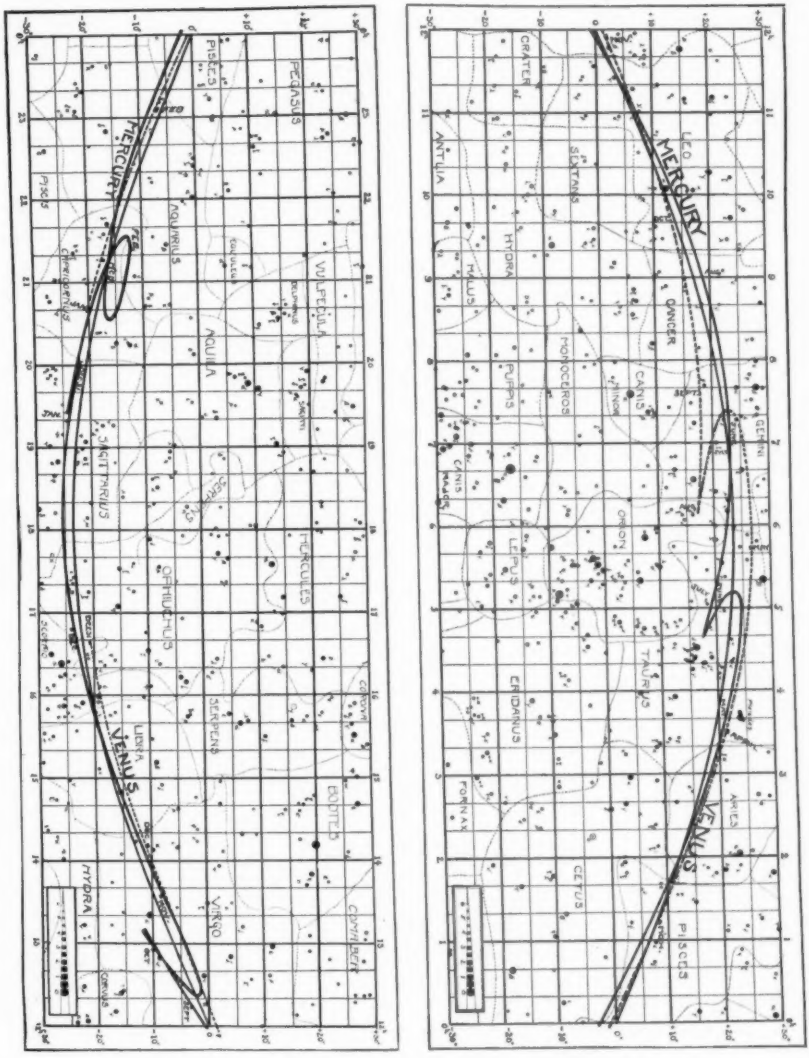



FIG. 1. Aparent paths of the planets Mercury and Venus among the stars during the year 1916.

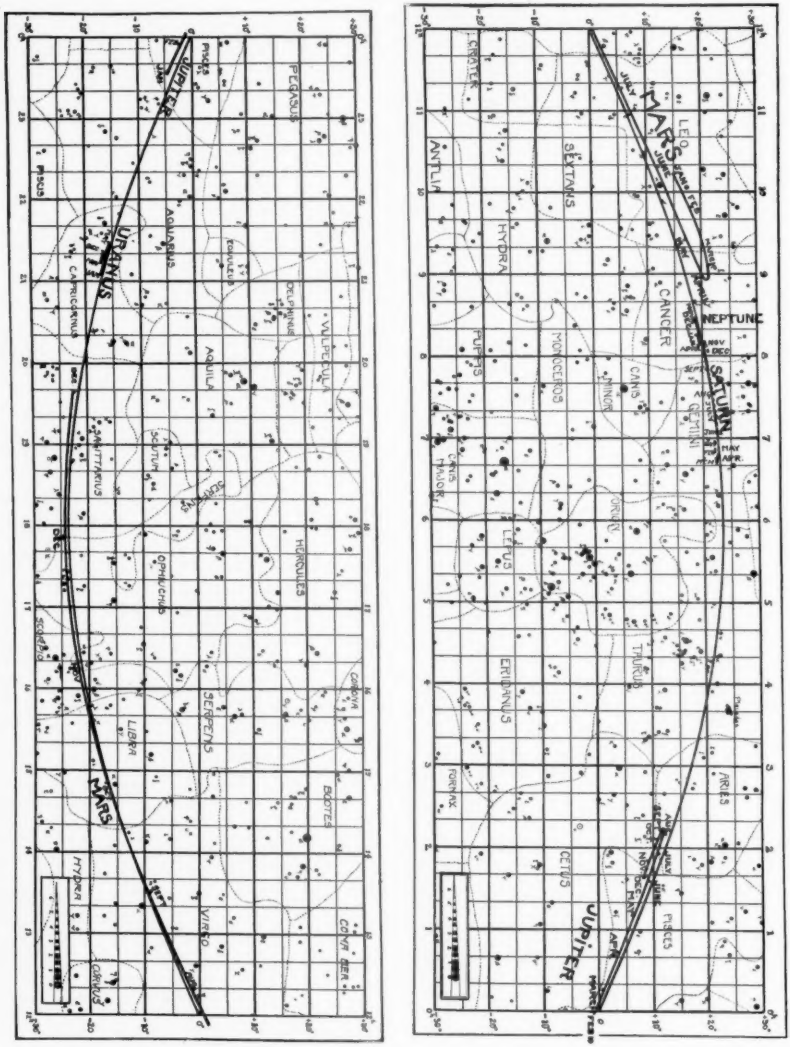



FIG. 2 Apparent paths of the planets Mars, Jupiter, Saturn, Uranus and Neptune among the stars during the year 1916.

NOTE:—Figures 1 and 2 were drawn by Carl D. Hibbard at Goodsell Observatory, the remaining figures were copied from the *American Ephemeris*.

and lower in the west and on May 27 will attain its greatest brilliancy. It will continue to move nearer to the sun and in June will no longer be visible. On July 3 it will pass between the sun and the earth. It will then swing out on the west side of the sun and be the bright morning star in August and will reach a point of greatest elongation west of the sun on September 12. It will remain a brilliant object in the morning sky throughout the remainder of the year.

*Mars* will begin the year with a motion westward in the constellation Leo. It will continue to move westward for the first three months and will then turn and move toward the east. It will keep ahead of the sun in its eastward course throughout the year. The sun will however be gaining upon it, and Mars will end

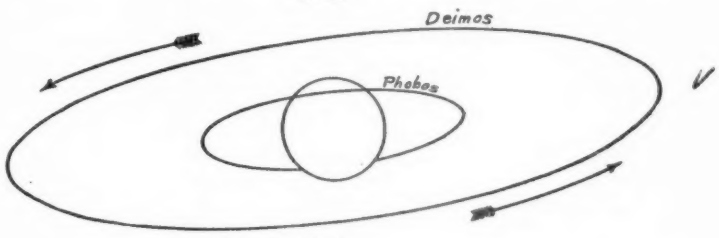



FIG. 3. SATELLITES OF MARS, 1916.
Apparent orbits of the Satellites of Mars at date of opposition, February 9, 1916, as seen in an inverting telescope.

the year low in the west at sunset. Mars will therefore be visible in the sky throughout the year. Mars will come to opposition in February, but it will not be a very favorable opposition, the distance from the earth being nearly twice as great as at the most favorable one.

Figure 3 shows the orbits of the satellites of Mars at the time of opposition.

*Jupiter* will move eastward starting from a point in Pisces to a point in Aries from January 1 to August 1. It will then take up a slow retrograde motion and end

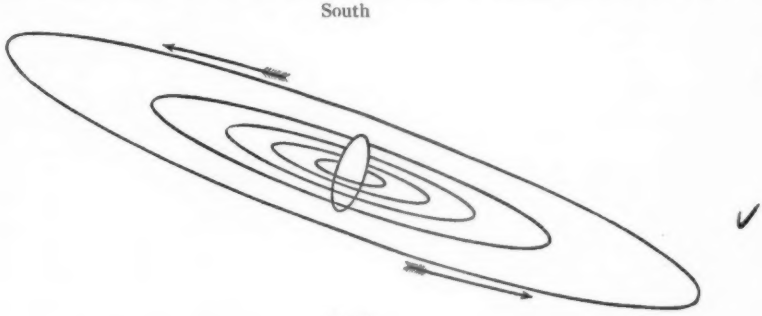



FIG. 4. SATELLITES OF JUPITER, 1916.
Apparent orbits of five of the satellites of Jupiter at date of opposition, October 23, 1916, as seen in an inverting telescope and elongated in the ratio of three to one in the direction of their minor axes.

the year near the eastern edge of Pisces. At the beginning of the year Jupiter will still be visible in the west at sunset. In March it will be lost in the rays of the sun and will be behind the sun from the earth on April 1. In May it will again appear in the morning sky. It will then rise earlier each morning and in the latter part of July it will rise at midnight. In October it will rise at sunset, and be visible in the early evening for the rest of the year.

Figure 4 shows the orbits of the satellites of Jupiter at the date of opposition, October 23.

*Saturn* will move first westward in Gemini, then eastward into Cancer, then westward again in Cancer during November and December. Saturn will be visible in the evening until the early part of the summer. During the summer it will be obscured by the sun. It will be behind the sun on July 12. About September 1 it

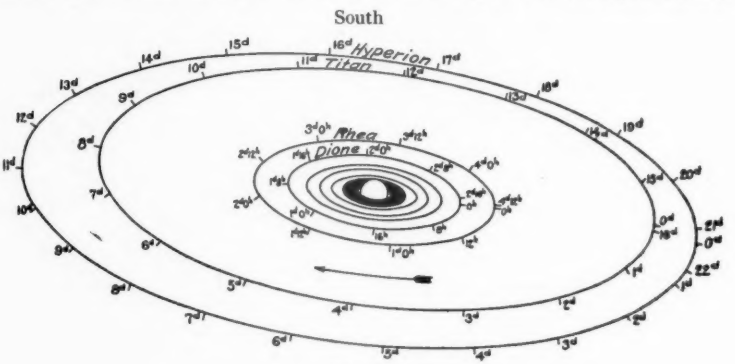



FIG 5. SATELLITES OF SATURN, 1916.
Apparent orbits of the seven inner satellites of Saturn at date of opposition, January 4, 1916, as seen in an inverting telescope.

will again appear in the morning sky. It will be most favorably situated for observation in the early part of the year, being at opposition on January 4. Figure 5 shows the orbits of the satellites of Saturn at this date.

*Uranus* moves back and forth as it did last year in the constellation Capricornus. It ends the year a little more than 4 degrees east of its starting point. Its real motion is toward the east, and its shifting position as seen in the figure is due to the earth's motion. Taking out of its total path its proper motion eastward, the remainder is due to parallax which is quite large in the case of Uranus and very small in the case of the distant stars. Uranus will be visible low in the west at sunset at the beginning of the year. It will then disappear in the rays of the sun and be back of the sun on February 5. In March it will again appear in the morning sky and be visible throughout the year. It will be best situated about August 10, being at opposition on this date. Figure 6 shows the orbits of its satellites at this date.

*Neptune* will have a motion similar to that described for Uranus. It however is in the constellation Cancer. It will be at opposition on January 22. During July and August it will not be visible because of the nearness of the sun. After this date it will again appear in the morning sky. Figure 7 shows the orbit of its satellite at the date of the opposition.

## COMETS.

The comet 1913 *f* (Delavan) which has been visible, except when too near the sun, since its discovery will still be visible at the beginning of the year in the larger telescopes in the southern hemisphere. According to computation it will be of about the eleventh magnitude. Comet 1915 *a* (Mellish) also will be visible at the beginning of the year. It will be visible in the northern hemisphere. It will be moving northwestwardly in the constellation Taurus, about an hour west of Aldebaran. It will be of the tenth magnitude and decreasing rapidly in brightness because it is rapidly receding from the sun. Comet 1915 *e* (Taylor) may be found at the beginning of the year according to the diagram in the comet notes in this number.

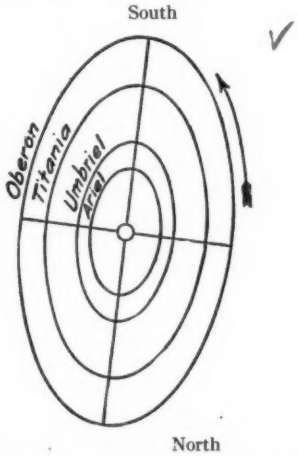



FIG. 6. SATELLITES OF URANUS, 1916. Apparent orbits of the satellites of Uranus at date of opposition, August 10, 1916 as seen in an inverting telescope.

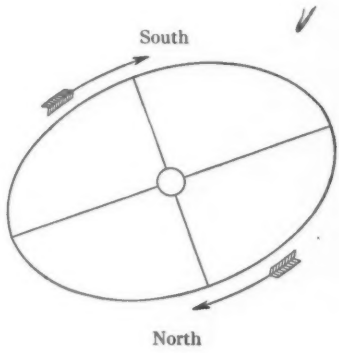



FIG. 7. SATELLITE OF NEPTUNE. 1916. Apparent orbit of the satellite of Neptune at date of opposition, January 22, 1916, as seen in an inverting telescope.

Of the periodic comets, five of those which have been seen only once and whose periods have been determined may possibly be seen again this year. Comet Barnard 1884 II is due at perihelion very early in 1917 and may be discovered in its approach during the latter part of 1916; Comet Perrine 1896 VII is due at perihelion, according to the period determined for it, about the middle of the year; Comet Giacobini 1896 V also is due to arrive at perihelion about the middle of the year; Comet Denning 1894 I is due to arrive at perihelion a little before the middle of the year; Comet 1909 *e* (Daniel) is due at perihelion sometime in April. Each of these comets as stated has been seen but once. The return predicted for this year is the sixth for Barnard's comet, the third for Perrine's, the third for Giacobini's, the third for Denning's and the first for Daniel's. The fact that they have escaped detection on several preceding returns to perihelion make it seem improbable that they will be seen at this time. It may be however that conditions this time will be more favorable than at the former returns.

## METEORS.

The sight of a meteor, or falling star, always attracts the attention of the observer, and if it happens to be a particularly brilliant one it arouses in those unacquainted with the phenomenon a feeling of awe, almost that of fear. Unless one deliberately sets out to observe meteors only an occasional one will be seen by him, and he will get the impression that they are not very numerous and that they occur only at night. However there is a continual bombardment of the earth, usually the earth's atmosphere only, by these small masses from space. Only the brightest ones at night are apparent, and practically none of those that fall in the day time. There are certain times in the year when special displays may be expected. The table following indicates these times with the place in the sky from which the meteors seem to come, and the character of the apparition.

| Date | Radiant | | Character |
|---|---|---|---|
| | $\alpha$ | $\delta$ | |
| | ° | ° | |
| Jan. 2-3 | 230 | +53 | Swift; long paths. |
| Apr. 20-22 | 271 | +33 | Swift. |
| May 1-6 | 338 | − 2 | Swift; streaks. |
| July 28-30 | 339 | −11 | Slow; long. |
| Aug. 10-13 | 46 | +57 | Swift; streaks. |
| Oct. 18-20 | 92 | +15 | Swift; streaks. |
| Nov. 14-16 | 150 | +22 | Swift; streaks. |
| Nov. 17-23 | 25 | +43 | Very slow; trains. |
| Dec. 10-12 | 108 | +33 | Swift; short. |

## VARIABLE STARS.

The predicted times of the maxima of certain short period variables and of the minima of certain others will be published from month to month in advance as in former years. These times are computed from the best elements that are available and the periods and times are corrected as new information comes to hand concerning any of these variables. Only a few of these stars are visible to the naked eye, but even a small telescope will enable the user of it to follow practically all of these stars through their light changes.

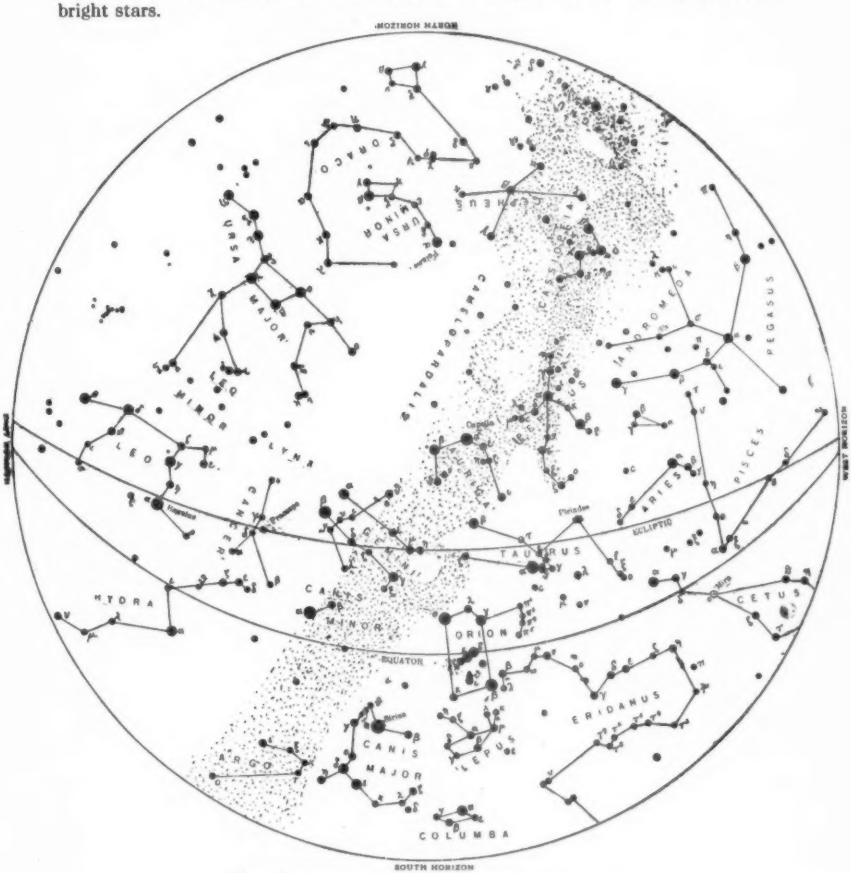
The times for this year have been computed at the Goodsell Observatory by Miss Agnes E. Wells, Miss Bertha Booth and Miss Bessie Burnham.

## OCCULTATIONS.

For the convenience of our readers who may not have access to the *American Ephemeris* the list of stars as given in this volume whose occultations by the moon are visible at Washington will be published one month in advance. It will be an interesting exercise for the observers with a telescope, a small one is as good as a large one for this purpose, to observe these occultations to see how well the times have been determined. This is one way by which the movement of the moon has been determined with such great accuracy.

## PLANET NOTES FOR FEBRUARY, 1916.

The sun will move in a northeasterly direction, passing from Capricornus into Aquarius during this month through a region in which there are no conspicuously bright stars.




THE CONSTELLATIONS AT 9:00 P. M. FEBRUARY 1.

The phases of the moon for this month are as follows:

| | | | | |
|---|---|---|---|---|
| New Moon | Feb. | 3 | at 10 A.M. | C.S.T. |
| First Quarter | | 10 | " 4 P.M. | " |
| Full Moon | | 18 | " 8 P.M. | " |
| Last Quarter | | 26 | " 3 A.M. | " |

The moon will come to perigee twice in this month, once on February 1, and again on February 29. It will be at apogee on February 13.

*Mercury* will continue to move from its position of greatest elongation east on January 20, westward toward the sun. It will be at a point of inferior conjunction with the sun on February 5. It will consequently be too close to the sun near this date to be visible. It will be very near a point of greatest elongation west at the close of the month. It will then be visible in the morning sky just before sunrise. It will rise about an hour and a half before the sun.

*Venus* will be the brilliant evening star during this month. It will be quite high in the sky at sunset. It will stand out brilliantly in a part of the sky which is free from bright stars. It will be more than ten times as bright as Aldebaran, a typical first magnitude star.

*Mars* will be in a very good position for observers. On February 9 it will be in opposition with the sun. Because it is considerably farther north than the sun it will rise before sunset and therefore will be well up in the sky for evening observation. It will approach the earth until February 9, and will then recede. It will not be very bright at this opposition since it will come only within about 60,000,000 miles of the earth.

*Jupiter* will be moving eastward much more slowly than the sun. It will therefore be lower in the west on each succeeding day. It will however continue to be visible throughout the month. Jupiter and Venus will be in the same part of the sky. Venus will pass Jupiter on February 13.

*Saturn* will continue throughout this month to be found in the constellation Gemini. As this is a winter constellation Saturn may be easily observed. It will be moving westward slowly during this month.

*Uranus* will be in conjunction with the sun on February 5. It will therefore be too close to the sun to be observed until very late in the month, and then it will be visible only in the early morning.

*Neptune* will be a few hours east of Saturn. It also will therefore be favorably situated. It will be moving slowly westward in the constellation Cancer.

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## Occultations Visible at Washington.

| Date 1916 | Star's Name | Magnitude | IMMERSION. Washington M.T. | Angle f'm N. | EMERSION. Washington M.T. | Angle f'm N. | Duration |
|---|---|---|---|---|---|---|---|
| | | | h m | ° | h m | ° | h m |
| Feb. 14 | $\epsilon$ Geminorum | 3.2 | 4 13 | 213 | 4 42 | 205 | 0 30 |
| 14 | $\omega$ Geminorum | 5.2 | 15 22 | 62 | 16 17 | 280 | 0 55 |
| 15 | B.D. + 23°1744 | 6.4 | 2 47 | 168 | 3 39 | 251 | 0 52 |
| 15 | 192 B Gemin. | 6.3 | 8 54 | 179 | 10 14 | 260 | 1 19 |
| 17 | $\pi$ Cancri | 5.6 | 4 52 | 165 | 5 51 | 280 | 0 59 |
| 21 | $q$ Virginis | 5.3 | 12 34 | 202 | 13 26 | 261 | 0 52 |
| 27 | 69 G Sagittarii | 6.3 | 15 2 | 109 | 15 56 | 303 | 0 54 |

## Saturn's Satellites for February, 1916.

CENTRAL STANDARD TIME.

E = eastern elongation; W = western elongation;
I = inferior conjunction; S = superior conjunction.

### I. Mimas. Period $0^d\ 22^h.6$.

| | d | h | | h | d | | d | h | | d | h |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb. | 1 | 16.2 W | Feb. | 8 | 17.8 E | Feb. | 15 | 19.3 W | Feb. | 23 | 19.7 E |
| | 2 | 14.8 W | | 9 | 16.4 E | | 16 | 18.0 W | | 24 | 18.3 E |
| | 3 | 13.4 W | | 10 | 15.0 E | | 17 | 16.6 W | | 25 | 10.9 E |
| | 4 | 12.0 W | | 11 | 13.6 E | | 18 | 15.2 W | | 26 | 15.5 E |
| | 5 | 10.6 W | | 12 | 12.2 E | | 19 | 13.9 W | | 27 | 14.2 E |
| | 5 | 22.0 E | | 13 | 10.8 E | | 20 | 12.5 W | | 28 | 12.8 E |
| | 6 | 20.6 E | | 13 | 22.1 W | | 21 | 11.1 W | | 29 | 11.4 E |
| | 7 | 19.2 E | | 14 | 20.7 W | | 22 | 21.1 E | | | |

### II. Enceladus. Period $1^d\ 8.9^h$.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb. | 1 | 12.5 E | Feb. | 8 | 8.9 E | Feb. | 15 | 5.4 E | Feb. | 22 | 1.8 E |
| | 2 | 21.4 E | | 9 | 17.8 E | | 16 | 14.2 E | | 23 | 10.7 E |
| | 4 | 6.3 E | | 11 | 2.7 E | | 17 | 23.1 E | | 24 | 19.5 E |
| | 5 | 15.2 E | | 12 | 11.6 E | | 19 | 8.0 E | | 26 | 4.4 E |
| | 7 | 0.1 E | | 13 | 20.5 E | | 20 | 16.9 E | | 27 | 13.3 E |
| | | | | | | | | | | 28 | 22.2 E |

### III. Tethys. Period $1^d\ 21^h.3$.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb. | 1 | 21.5 E | Feb. | 9 | 10.7 E | Feb. | 17 | 0.0 E | Feb. | 24 | 13.2 E |
| | 3 | 18.8 E | | 11 | 8.1 E | | 18 | 21.3 E | | 26 | 10.5 E |
| | 5 | 16.1 E | | 13 | 5.4 E | | 20 | 18.6 E | | 28 | 7.8 E |
| | 7 | 13.4 E | | 15 | 2.7 E | | 22 | 15.9 E | | | |

### IV. Dione. Period $2^d\ 17^h.7$.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb. | 2 | 4.3 E | Feb. | 10 | 9.3 E | Feb. | 18 | 14.3 E | Feb. | 26 | 19.3 E |
| | 4 | 22.0 E | | 13 | 3.0 E | | 21 | 8.0 E | | 29 | 13.0 E |
| | 7 | 15.7 E | | 15 | 20.6 E | | 24 | 3.7 E | | | |

### V. Rhea. $4^d\ 12^h.5$.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb. | 4 | 10.3 E | Feb. | 13 | 11.0 E | Feb. | 22 | 11.8 E | Feb. | 27 | 0.2 E |
| | 8 | 22.7 E | | 18 | 23.4 E | | | | | | |

### VI. Titan. Period $15^d\ 23^h.3$.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feb. | 6 | 12.8 E | Feb. | 14 | 4.8 W | Feb. | 22 | 10.8 E | | | |

### VII. Hyperion. Period $21^d\ 7^h.6$.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Feb. | 10 | 7.1 W | Feb. | 19 | 23.0 E | | | |

### VIII. Japetus. Period $79^d\ 22^h.1$.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Feb. | 3 | 9.4 S | Feb. | 23 | 21.6 E | | | |

### IX. Phoebe. Period $523^d\ 15^h.6$.

| | | α Ph. — α Sat. | | δ Ph. — δ Sat. | | | α Ph. — α Sat. | | δ Ph. — δ Sat. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | m | s | ′ | ″ | | m | s | ′ | ″ |
| Feb. | 2 | +0 | 4.5 | +3 | 14 | Feb 16 | −0 | 14.4 | +3 | 11 |
| | 4 | +0 | 1.8 | 3 | 14 | 11 | 0 | 17.1 | 3 | 10 |
| | 6 | −0 | 0.9 | 3 | 14 | 20 | 0 | 19.8 | 3 | 9 |
| | 8 | 0 | 3.6 | 3 | 14 | 22 | 0 | 22.5 | 3 | 7 |
| | 10 | 0 | 6.3 | 3 | 13 | 24 | 0 | 25.2 | 3 | 6 |
| | 12 | 0 | 9.0 | 3 | 13 | 26 | 0 | 27.9 | 3 | 5 |
| | 14 | −0 | 11.7 | +3 | 12 | 28 | 0 | 30.6 | 3 | 3 |

## VARIABLE STARS.

### Approximate Magnitudes of Variable Stars of Long Period on Dec. 1, 1915.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

| Name. | R. A. 1900. h m | Decl. 1900. ° ′ | Magn. | Name. | R.A. 1900 h m | Decl. 1900 ° ′ | Magn. |
|---|---|---|---|---|---|---|---|
| X Androm. | 0 10.8 | +46 27 | <14.0 | R Aurigae | 5 9.2 | +53 28 | 14.0*d* |
| T Androm. | 17.2 | +26 26 | 9.5*d* | W Aurigae | 20.1 | +36 49 | 13.0*d* |
| T Cassiop. | 17.8 | +55 14 | 9.0 *i* | S Aurigae | 20.5 | +34 4 | 9.3 |
| R Androm. | 18.8 | +38 1 | 13.8*d* | S Orionis | 24.1 | — 4 46 | 8.4*d* |
| S Ceti | 19.0 | — 9 53 | 8.5*d* | S Camelop. | 30.2 | +68 45 | 8.8*d* |
| Y Cephei | 31.3 | +79 48 | 9.8 *i* | T Orionis | 30.9 | — 5 32 | 10.0*d* |
| U Cassiop. | 40.8 | +47 43 | 9.0*d* | U Aurigae | 35.6 | +31 59 | 13.0 |
| RW Androm. | 41.9 | +32 8 | 13.8*d* | SU Tauri | 43.2 | +19 2 | 10.0 |
| V Androm. | 44.6 | +35 6 | 9.7 *i* | V Camelop. | 49.4 | +74 30 | 11.1 *i* |
| RR Androm. | 45.9 | +33 50 | 10.9*d* | U Orionis | 49.9 | +20 10 | 10.4*d* |
| RV Cassiop | 47.1 | +46 53 | 11.3*d* | Z Aurigae | 53.6 | +53 18 | 9.0 |
| W Cassiop. | 49.0 | +58 1 | 11.5*d* | X Aurigae | 6 4.4 | +50 15 | 8.9 *i* |
| Z Ceti | 1 1.6 | — 2 1 | 13.1*d* | SS Aurigae | 5.8 | +47 46 | <14.0 |
| U Androm. | 9.8 | +40 11 | 10.6 *i* | V Aurigae | 16.5 | +47 45 | 9.0 |
| S Cassiop. | 12.3 | +72 5 | 13.8*d* | V Monoc. | 17.7 | — 2 9 | 8.9 *i* |
| S Piscium | 12.4 | + 8 24 | 10.0 *i* | U Lyncis | 31.8 | +59 57 | 13.6*d* |
| U Piscium | 17.7 | +12 21 | 12.3 *i* | S Lyncis | 35.9 | +58 0 | 10.1 *i* |
| RZ Persei | 23.6 | +50 20 | 13.0*d* | Y Monoc. | 51.3 | +11 22 | 9.0 *i* |
| R Piscium | 25.5 | + 2 22 | 9.1*d* | X Monoc. | 52.4 | — 8 56 | 7.8 |
| RU Androm. | 32.8 | +38 10 | 11.0*d* | R Lyncis | 53.0 | +55 28 | 13.0 |
| Y Androm. | 33.7 | +38 50 | 10.9*d* | R Geminorum | 7 1.3 | +22 52 | 7.8*d* |
| X Cassiop. | 49.8 | +58 46 | 11.8 *i* | V Can. Min. | 1.5 | + 9 2 | 10.0*d* |
| U Persei | 53.0 | +54 20 | 8.6 | R Can. Min. | 3.2 | +10 11 | 10.0*d* |
| S Arietis | 59.3 | +12 3 | <14.0 | RR Monoc. | 12.4 | + 1 17 | <13.0 |
| R Arietis | 2 10.4 | +24 35 | 12.3*d* | S Can. Min. | 27.3 | + 8 32 | 8.0 *i* |
| W Androm. | 11.2 | +43 50 | 13.8 | Z Puppis | 28.3 | −20 27 | 13.0 |
| Z Cephei | 12.8 | +81 13 | <14.0 | T Can. Min. | 28.4 | +11 58 | 9.5 |
| *o* Ceti | 14.3 | — 3 26 | 4.0 *i* | U Can. Min. | 35.9 | + 8 37 | 9.5 |
| S Persei | 15.7 | +58 8 | 9.0′ | S Geminorum | 37.0 | +23 41 | 13.5 |
| R Ceti | 20.9 | — 0 38 | 11.0 *i* | T Geminorum | 43.3 | +23 59 | 9.2 |
| RR Persei | 21.7 | +50 49 | 12.2*d* | U Puppis | 56.1 | −12 34 | 13.0 |
| U Ceti | 28.9 | −13 35 | 8.9*d* | R Cancri | 8 11.0 | +12 2 | 11.3 |
| RR Cephei | 29.4 | +80 42 | 13.8 | V Cancri | 16.0 | +17 36 | 11.0 *i* |
| R Trianguli | 31.0 | +33 50 | 10.0 *i* | RT Hydrae | 24.7 | — 5 59 | 8.5 |
| W Persei | 43.2 | +56 34 | 10.3 | U Cancri | 30.0 | +19 14 | 10.8*d* |
| U Arietis | 3 5.5 | +14 25 | 13.0 *i* | S Hydrae | 48.4 | + 3 27 | 8.2 *i* |
| X Ceti | 14.3 | — 1 26 | 9.0*d* | T Hydrae | 50.8 | — 8 46 | 8.0 |
| Y Persei | 20.9 | +43 50 | 9.8 | T Cancri | 51.0 | +20 14 | 9.0 |
| R Persei | 23.7 | +35 20 | 10.0*d* | S Pyxidis | 9 0.7 | −24 41 | 11.0 *i* |
| Nov. Per. No. 2 | 24.4 | +43 34 | 13.5*d* | W Cancri | 4.0 | +25 39 | 13.0 |
| W Tauri | 4 22.2 | +15 49 | 12.0 *i* | X Hydrae | 30.7 | −14 15 | 12.0 |
| R Tauri | 22.8 | + 9 56 | 13.8*d* | Y Draconis | 31.1 | +78 18 | 13.6*d* |
| S Tauri | 23.7 | + 9 44 | <14.0 | R Leo. Min. | 39.6 | +34 58 | 9.8 *i* |
| T Camelop. | 30.4 | +65 57 | 13.7*d* | RR Hydrae | 40.4 | −23 34 | <13.5 |
| X Camelop. | 32.6 | +74 56 | 9.0*d* | R Leonis | 42.2 | +11 54 | 5.5 |
| RX Tauri | 32.8 | + 8 9 | 9.0 | Y Hydrae | 46.4 | −22 33 | 6.8 |
| V Tauri | 46.2 | +17 22 | 10.3 *i* | V Leonis | 54.5 | +21 44 | 8.8 |
| R Orionis | 53.6 | + 7 59 | 13.3 | R Urs. Maj. | 10 37.6 | +69 18 | 7.7 |
| R Leporis | 55.0 | −14 57 | 7.0 | V Hydrae | 46.8 | −20 43 | 7.5 |
| T Leporis | 5 0.6 | −22 2 | 8.8 *i* | W Leonis | 48.4 | +14 15 | 10.8 |
| V Orionis | 0.8 | + 3 58 | 12.4 | S Leonis | 11 5.7 | + 6 0 | 10.8 *i* |

## Approximate Magnitudes of Variable Stars of Long Period on Dec. 1, 1915—Continued.

| Name. | R. A. 1900. | Decl. 1900 | Magn. | Name. | R. A. 1900. | Decl. 1900 | Magn. |
|---|---|---|---|---|---|---|---|
| | h m | ° ′ | | | h m | ° ′ | |
| R Com. Ber. | 11 59.1 | +19 20 | 14.0*d* | U Lyrae | 19 16.6 | +37 42 | 12.7*d* |
| T Urs. Maj. | 12 31.8 | +60 2 | 9 .6*d* | TY Cygni | 29.8 | +28 6 | 13.7 |
| RS Urs. Maj. | 34.4 | +59 2 | 10.6 *i* | RT Aquilae | 33.3 | +11 30 | 14.0 |
| S Urs. Maj. | 39.6 | +61 38 | 8.8 *i* | R Cygni | 34.1 | +49 58 | 11.8*d* |
| T Urs. Min. | 13 32.6 | +73 56 | 10.8*d* | RV Aquilae | 35.9 | + 9 42 | 12.6*d* |
| R Can. Ven. | 44.6 | +40 2 | 8.8 *i* | RT Cygni | 40.8 | +48 32 | 8.8*d* |
| U Urs. Min. | 14 15.1 | +67 15 | 8.1 | TU Cygni | 43.3 | +48 49 | 9.7*d* |
| S Bootis | 19.5 | +54 16 | 10.2*d* | X Aquilae | 46.5 | + 4 13 | 13.8 |
| R Camelop. | 25.1 | +84 17 | 11.8*d* | χ Cygni | 46.7 | +32 40 | 9.6 *i* |
| V Bootis | 25.7 | +39 18 | 7.6 | RR Aquilae | 52.4 | − 2 11 | 9.0 |
| S Urs. Min. | 15 33.4 | +78 58 | 12.2 | RS Aquilae | 53.7 | − 8 9 | 9.8 |
| R Cor.Bor. | 44.4 | +28 28 | 6.0 | Z Cygni | 58.6 | +49 46 | 9.8 *i* |
| X Cor. Bor. | 45.2 | +36 35 | 9.6 | SY Aquilae | 20 2.3 | +12 39 | 13.0 |
| V Cor. Bor. | 46.0 | +39 52 | 8.2 | S Cygni | 3.4 | +57 42 | 12.7 *i* |
| W Cor. Bor. | 16 11.8 | +38 3 | 8.2 *i* | R Capricorni | 5.7 | −14 34 | 12.6*d* |
| U Herculis | 21.4 | +19 7 | 12.0*d* | S Aquilae | 7.0 | +15 19 | 9.4 *i* |
| R Urs. Min. | 31.3 | +72 28 | 9.8 | RU Aquilae | 8.0 | +12 42 | 10.5*d* |
| W Herculis | 31.7 | +37 32 | 13.5*d* | W Capricorni | 8.6 | −22 17 | 13.5*d* |
| R Draconis | 32.4 | +66 58 | 11.7*d* | RS Cygni | 9.8 | +38 28 | 7.6 |
| RV Herculis | 56.8 | +31 22 | <14.0 | Z Aquilae | 9.8 | − 6 27 | 10.1 *i* |
| RT Herculis | 17 6.8 | +27 11 | 13.6*d* | R Delphini | 10.1 | + 8 47 | 13.2 |
| RS Herculis | 17.5 | +23 1 | 9.6*d* | RT Capricorni | 11.3 | −21 38 | 7.5 |
| RU Ophiuchi | 28.1 | + 9 30 | 9.0 | SX Cygni | 11.6 | +30 46 | 14.0 |
| RT Ophiuchi | 51.8 | +11 11 | <13.5 | U Cygni | 16.5 | +47 35 | 7.3 |
| T Draconis | 54.8 | +58 14 | 10.2 | RU Capricorni | 26.7 | −22 2 | 10.0 |
| RY Herculis | 55.4 | +19 29 | 11.0 *i* | Z Delphini | 28.1 | +17 7 | 13.0*d* |
| V Draconis | 56.3 | +54 53 | 9.8*d* | ST Cygni | 29.9 | +54 38 | 11.0*d* |
| T Herculis | 18 5.3 | +31 0 | 10.6 *i* | Y Delphini | 36.9 | +11 31 | 13.3*d* |
| W Draconis | 5.4 | +65 56 | 9.5 *i* | V Cygni | 38.1 | +47 47 | 8.5 |
| X Draconis | 6.8 | +66 8 | 10.6 *i* | S Delphini | 38.5 | +16 44 | 10.1 *i* |
| W Lyrae | 11.5 | +36 38 | 11.7 *i* | Y Aquarii | 39.2 | − 5 12 | <13.0 |
| RY Ophiuchi | 11.6 | + 3 40 | 8.5 | T Delphini | 40.7 | +16 2 | 13.4*d* |
| SV Herculis | 22.3 | +24 58 | 10.1*d* | W Aquarii | 41.2 | − 4 27 | 13.0 |
| T Serpentis | 23.9 | + 6 14 | <13.5 | U Capricorni | 42.6 | −15 9 | 13.8 |
| SV Draconis | 31.2 | +49 18 | 13.8 | V Delphini | 43.2 | +18 58 | 10.2*d* |
| RZ Herculis | 32.7 | +25 58 | 11.5*d* | T Aquarii | 44.7 | − 5 31 | 11.1*d* |
| X Ophiuchi | 33.6 | + 8 44 | 8.0 | RZ Cygni | 48.5 | +46 59 | 11.8*d* |
| RY Lyrae | 41.2 | +34 34 | 13.2 *i* | X Delphini | 50.3 | +17 16 | 13.1*d* |
| RW Lyrae | 42.1 | +43 32 | 11.8 | R Vulpeculae | 59.9 | +23 26 | 9.0 *i* |
| R Scuti | 42.2 | − 5 49 | 5.0 | TW Cygni | 21 1.8 | +29 0 | 13.8*d* |
| RX Lyrae | 50.4 | +32 42 | <13.5 | V Capricorni | 1.8 | −24 19 | 9.0 *i* |
| ST Sagittarii | 55.9 | −12 54 | 13.0*d* | X Capricorni | 2.8 | −21 45 | <13.5 |
| Z Lyrae | 56.0 | +34 49 | <13.5 | X Cephei | 3.6 | +82 40 | 10.6*d* |
| RT Lyrae | 57.8 | +37 22 | 12.5 *i* | Z Capricorni | 5.0 | −16 35 | 12.5*d* |
| R Aquilae | 19 1.6 | + 8 5 | 8.2*d* | RS Aquarii | 5.8 | − 4 27 | 13.0 *i* |
| V Lyrae | 5.2 | +29 30 | <13.5 | T Cephei | 8.2 | +68 5 | 6.4 *i* |
| RW Sagittarii | 8.1 | −19 2 | 12.0*d* | R Equulei | 8.4 | +12 23 | 11.8*d* |
| RX Sagittarii | 8.7 | −18 59 | 9.9 | RR Aquarii | 9.8 | − 3 19 | 12.0*d* |
| RU Lyrae | 9.1 | +41 8 | 8.0 | X Pegasi | 16.3 | +14 2 | 14.0*d* |
| S Lyrae | 9.1 | +25 50 | <14.0 | T Capricorni | 16.5 | −15 35 | 13.5 |
| RS Lyrae | 9.3 | +33 15 | 13.0 | Y Capricorni | 28.9 | −14 25 | 12.0 *i* |
| U Draconis | 9.9 | +67 7 | 11.7 *i* | S Cephei | 36.5 | +78 10 | 10.2 *i* |
| W Aquilae | 10.0 | − 7 13 | <14.0 | RU Cygni | 37.3 | +53 52 | 8.0 |
| T Sagittarii | 10.5 | −17 9 | 9.6 *i* | SS Cygni | 38.8 | +43 8 | 12.0 |
| R Sagittarii | 10.8 | −19 29 | 7.4*d* | RR Pegasi | 40.0 | +24 33 | 14.2*d* |
| TZ Cygni | 13.4 | +50 0 | 10.4 | V Pegasi | 56.0 | + 5 38 | <13.5 |
| S Sagittarii | 13.6 | −19 12 | 9.6 *i* | RT Pegasi | 59.8 | +34 38 | 9.6 *i* |
| Z Sagittarii | 13.8 | −21 7 | 13.0*d* | T Pegasi | 22 4.0 | +12 3 | <13.5 |

## Approximate Magnitudes of Variable Stars of Long Period on Dec. 1, 1915—Continued.

| Name. | R. A. 1900. h m | Decl. 1900. ° ′ | Magn. | Name. | R.A. 1900. h m | Decl. 1900. ° ′ | Magn. |
|---|---|---|---|---|---|---|---|
| Y Pegasi | 22 6.8 | +13 52 | <14.0 | Z Androm. | 23 28.8 | +48 16 | 11.0 |
| RS Pegasi | 7.4 | +14 4 | 9.0 *i* | ST Androm. | 33.8 | +35 13 | 10.8*d* |
| RV Pegasi | 21.0 | +29 58 | 12.8 *i* | R Aquarii | 38.6 | −15 50 | 9.0*d* |
| S Lacertae | 24.6 | +39 48 | 11.8*d* | Z Cassiop. | 39.7 | +56 2 | 14.0 |
| R Lacertae | 38.8 | +41 51 | 8.4 *i* | RR Cassiop. | 50.7 | +53 8 | 12.2 |
| S Aquarii | 51.8 | −20 53 | 8.3 *i* | V Ceti | 52.8 | − 9 31 | 11.8 *i* |
| RW Pegasi | 59.2 | +14 46 | 10.8 *i* | R Cassiop. | 53.3 | +50 50 | 7.0 |
| R Pegasi | 23 1.6 | +10 0 | 7.3 *i* | Z Pegasi | 55.0 | +25 21 | 9.7 |
| V Cassiop. | 7.4 | +59 8 | 8.8*d* | Y Cassiop | 58.2 | +55 7 | 14.0 |
| W Pegasi | 14.8 | +25 44 | 12.8*d* | SV Androm. | 59.2 | +39 33 | 12.7*d* |
| S Pegasi | 15.5 | + 8 22 | 13.2*d* | | | | |

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:—H. C. Bancroft, Jr., T. C. H. Bouton, A. B. Burbeck, L. Campbell, H. O. Eaton, G. L. Harrell, W. P. Hoge, S. C. Hunter, O. Mach, C. Y. McAteer, C. S. Mundt, G. F. Nolte, W. T. Olcott, D. B. Pickering, C. F. Richter, F. H. Spinney, H. M. Swartz, I. E. Woods, and A. S. Young.

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## Maxima of Variable Stars of Short Period.

[Calculated by Bertha Booth and Bessie Burnham at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5$^h$; Central standard time 6$^h$; etc.

| Star | R. A. 1900 h m | Decl. 1900 ° ′ | Magnitude | Approx. Period d h | Greenwich mean times of maxima in 1916. February d h | d h | d h | d h |
|---|---|---|---|---|---|---|---|---|
| SX Cassiop. | 0 05.5 | +54 20 | 8.6— 9.4 | 36 13.7 | | 16 13 | | |
| SY Cassiop. | 0 09.8 | +57 52 | 9.3— 9.9 | 4 1.7 | 4 22; | 13 2; | 21 5; | 29 8 |
| RR Ceti | 1 27.0 | + 0 50 | 8.3— 9.0 | 0 13.3 | 5 5; | 12 23; | 20 17; | 28 11 |
| RW Cassiop. | 1 30.7 | +57 15 | 8.9—11.0 | 14 19.2 | 1 17; | 16 12 | | |
| V Arietis | 2 09.6 | +11 46 | 8.3— 9.0 | 0 23.8 | 7 4; | 15 2; | 23 1 | |
| SU Cassiop. | 2 43.0 | +68 28 | 6.5— 7.0 | 1 22.8 | 6 18; | 14 13; | 22 8 | |
| TU Persei | 3 01.8 | +52 49 | 11.4—12.2 | 0 14.6 | 8 6; | 15 13; | 22 20 | |
| RW Camelop. | 3 46.2 | +58 21 | 8.2— 9.4 | 16 00.0 | 3 0; | 19 0 | | |
| SX Persei | 4 10.2 | +41 27 | 10.4—11.2 | 4 07.0 | 6 1; | 14 15; | 23 5 | |
| SV Persei | 42.8 | +42 07 | 8.8— 9.6 | 11 03.1 | 8 7; | 19 10 | | |
| RX Aurigae | 4 54.5 | +39 49 | 7.2— 8.1 | 11 15.0 | 2 14; | 14 5; | 25 20 | |
| SX Aurigae | 5 04.6 | +42 02 | 8.0— 8.7 | 1 12.8 | 7 8; | 15 0; | 22 16 | |
| SY Aurigae | 05.5 | +42 41 | 8.4— 9.5 | 10 03.3 | | 10 22; | 21 1 | |
| Y Aurigae | 21.5 | +42 21 | 8.6— 9.6 | 3 20.6 | 6 10; | 14 3; | 21 21; | 29 14 |
| RZ Gemin. | 5 56.6 | +22 15 | 9.1—10.0 | 5 12.7 | 6 5; | 17 6; | 22 19; | 28 7 |
| RS Orionis | 6 16.5 | +14 44 | 8.2— 8.9 | 7 13.6 | 6 5; | 13 19; | 21 9; | 28 22 |
| T Monoc. | 19.8 | + 7 08 | 5.7— 6.8 | 27 00.3 | 3 17 | | | |
| RZ Camelop. | 23.7 | +67 06 | 11.0—13.0 | 0 11.5 | 7 16; | 14 21; | 22 2; | 29 7 |
| W Gemin. | 29.2 | +15 24 | 6.7— 7.5 | 7 22.0 | 3 9; | 11 7; | 19 5; | 27 3 |
| ζ Gemin. | 6 58.2 | +20 43 | 3.7— 4.3 | 10 03.7 | 1 23; | 11 3; | 21 7 | |

**Maxima of Variable Stars of Short Period—Continued.**

| Star | R.A. 1900 | Decl. 1900 | Magnitude | Approx. Period | Greenwich mean times of maxima in 1916. February | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | h m | ° ′ | | d h | d h | d h | d h | d h | d h | d h | d h | d h |
| RU Camelop. | 7 10.9 | +69 51 | 8.5— 9.8 | 22 06.5 | | 22 0 | | | | | | |
| RR Gemin. | 7 15.2 | +31 04 | 10.0—11.5 | 0 09.5 | 5 10; | 13 9; | 21 8; | 29 6 | | | | |
| V Carinae | 8 26.7 | −59 47 | 7.4— 8.1 | 6 16.7 | 4 9; | 11 2; | 17 19; | 24 11 | | | | |
| T Velorum | 8 34.4 | −47 01 | 7.6— 8.5 | 4 15.3 | 2 0; | 11 7; | 20 14; | 29 20 | | | | |
| V Velorum | 9 19.2 | −55 32 | 7.5— 8.2 | 4 08.9 | 2 3; | 10 21; | 19 15; | 28 9 | | | | |
| Z Leonis | 9 46.4 | +27 22 | 7.9— 9.6 | 59 0.0 | | | | | | | | |
| RR Leonis | 10 02.1 | +24 29 | 9.1—10.1 | 0 10.9 | 3 22; | 10 16; | 17 11; | 24 6 | | | | |
| SU Draconis | 11 32.2 | +67 53 | 8.9— 9.6 | 0 15.8 | 5 2; | 11 17; | 18 7; | 24 22 | | | | |
| S Muscae | 12 07.4 | −69 36 | 6.4— 7.3 | 9 15.8 | 6 15; | 16 7; | 25 23 | | | | | |
| SW Draconis | 12.8 | +70 04 | 8.8— 9.6 | 0 13.7 | 7 21; | 15 20; | 23 20 | | | | | |
| T Crucis | 15.9 | −61 44 | 6.8— 7.6 | 6 17.6 | 4 19; | 11 13; | 18 6; | 25 0 | | | | |
| R Crucis | 18.1 | −61 04 | 6.8— 7.9 | 5 19.8 | 4 20; | 10 16; | 22 8; | 28 3 | | | | |
| S Crucis | 12 48.4 | −57 53 | 6.5— 7.6 | 4 16.6 | 4 16; | 14 1; | 23 10; | 28 3 | | | | |
| W Virginis | 13 20.9 | − 2 52 | 8.7—10.4 | 17 06.5 | | 18 0 | | | | | | |
| SS Hydrae | 25.0 | −23 08 | 7.4— 8.1 | 8 4.8 | 2 14; | 10 19; | 19 0; | 27 5 | | | | |
| RV Urs. Maj. | 13 29.4 | +54 31 | 9.2— 9.9 | 0 11.2 | 7 11; | 14 12; | 21 12; | 28 13 | | | | |
| ST Virginis | 14 22.5 | − 0 27 | 10.3—11.4 | 0 09.9 | 8 1; | 16 6; | 24 11 | | | | | |
| V Centauri | 25.4 | −56 27 | 6.4— 7.8 | 5 11.9 | 4 13; | 10 1; | 21 1; | 26 12 | | | | |
| RS Bootis | 29.3 | +32 11 | 8.9—10.0 | 0 09.1 | 5 12; | 13 1; | 20 14; | 28 3 | | | | |
| RU Bootis | 14 41.5 | +23 44 | 12.8—14.3 | 0 11.9 | 3 16; | 11 2; | 18 12; | 25 22 | | | | |
| R Triang. Austr. | 15 10.8 | −66 08 | 6.7— 7.4 | 3 09.3 | 4 18; | 11 13; | 18 7; | 25 2 | | | | |
| S Triang. Austr. | 15 52.2 | −63 29 | 6.4— 7.4 | 6 07.8 | 3 14; | 9 21; | 22 13; | 28 21 | | | | |
| S Normae | 16 10.6 | −57 39 | 6.6— 7.6 | 9 18.1 | 6 12; | 16 6; | 25 23 | | | | | |
| RW Draconis | 33.7 | +58 03 | 9.6—10.8 | 0 10.6 | 3 15; | 12 12; | 21 8 | | | | | |
| RV Scorpii | 16 51.8 | −33 27 | 6.7— 7.4 | 6 01.5 | 6 7; | 12 9; | 18 10; | 24 12 | | | | |
| X Sagittarii | 17 41.3 | −27 48 | 4.4— 5.0 | 7 00.3 | 1 20; | 8 20; | 22 21; | 29 21 | | | | |
| Y Ophiuchi | 47.3 | − 6 07 | 6.1— 6.5 | 17 02.9 | 7 7; | 24 10 | | | | | | |
| W Sagittarii | 17 58.6 | −29 35 | 4.3— 5.1 | 7 14.3 | 7 20; | 15 10; | 23 0 | | | | | |
| Y Sagittarii | 18 15.5 | −18 54 | 5.4— 6.2 | 5 18.6 | 2 7; | 8 2; | 19 15; | 25 10 | | | | |
| U Sagittarii | 26.0 | −19 12 | 6.5— 7.3 | 6 17.9 | 3 10; | 10 4; | 16 22; | 23 16 | | | | |
| Y Scuti | 32.6 | − 8 27 | 8.7— 9.2 | 10 08.3 | 7 0; | 17 8; | 27 16 | | | | | |
| Y Lyrae | 34.2 | +43 52 | 11.3—12.3 | 0 12.1 | 5 19; | 11 19; | 23 21; | 29 22 | | | | |
| RZ Lyrae | 39.9 | +32 42 | 9.9—11.2 | 0 12.3 | 4 5; | 10 8; | 22 15; | 28 18 | | | | |
| RT Scuti | 44.1 | −10 30 | 9.1— 9.7 | 0 11.9 | 5 5; | 11 3; | 17 2; | 29 0 | | | | |
| κ Pavonis | 18 46.6 | −67 22 | 3.8— 5.2 | 9 02.2 | 8 13; | 17 15; | 26 17 | | | | | |
| U Aquilae | 19 24.0 | − 7 15 | 6.2— 6.9 | 7 00.6 | 1 19; | 8 20; | 22 21; | 29 21 | | | | |
| XZ Cygni | 30.4 | +56 10 | 8.6— 9.3 | 0 11.2 | 2 6; | 9 6; | 16 6; | 23 6 | | | | |
| U Vulpec. | 32.2 | +20 07 | 6.5— 7.6 | 7 23.5 | 1 12; | 9 12; | 17 11; | 25 11 | | | | |
| SU Cygni | 40.8 | +29 01 | 6.2— 7.0 | 3 20.3 | 7 21; | 15 14; | 23 6 | | | | | |
| η Aquilae | 47.4 | + 0 45 | 3.7— 4.5 | 7 04.2 | 4 10; | 11 15; | 18 19; | 25 23 | | | | |
| S Sagittae | 51.5 | +16 22 | 5.6— 6.4 | 8 09.2 | 1 23; | 10 8; | 18 17; | 27 3 | | | | |
| X Vulpec. | 19 53.3 | +26 17 | 9.5—10.5 | 6 07.7 | 1 7; | 7 15; | 20 6; | 26 14 | | | | |
| X Cygni | 20 39.5 | +35 14 | 6.0— 7.0 | 16 09.3 | | 12 18; | 29 3 | | | | | |
| T Vulpec. | 47.2 | +27 52 | 5.5— 6.1 | 4 10.5 | 3 23; | 12 20; | 21 17; | 26 3 | | | | |
| WY Cygni | 52.3 | +30 03 | 9.6—10.4 | 0 13.5 | 5 16; | 12 10; | 19 3; | 25 20 | | | | |
| RV Capric. | 55.9 | −15 37 | 9.2—10.1 | 0 10.7 | 5 1; | 11 18; | 18 12; | 25 5 | | | | |
| TX Cygni | 20 56.4 | +42 12 | 8.5— 9.7 | 14 17.4 | | 7 3; | 21 21 | | | | | |
| VY Cygni | 21 00.4 | +39 34 | 8.8— 9.5 | 7 20.6 | 3 21; | 11 18; | 19 14; | 27 11 | | | | |
| SW Aquarii | 10.2 | − 0 20 | 9.9—10.8 | 0 11.0 | 4 23; | 11 20; | 18 17; | 25 15 | | | | |
| VZ Cygni | 21 47.7 | +42 40 | 8.2— 9.2 | 4 20.7 | 5 10; | 14 22; | 24 16; | 29 13 | | | | |
| Y Lacertae | 22 05.2 | +50 33 | 9.1— 9.6 | 4 07.8 | 9 2; | 17 17; | 26 9 | | | | | |
| δ Cephei | 25.5 | +57 54 | 3.7— 4.6 | 5 08.8 | 5 20; | 11 5; | 21 23; | 27 8 | | | | |
| Z Lacertae | 36.9 | +56 18 | 8.2— 9.0 | 10 21.1 | 7 16; | 18 13; | 29 11 | | | | | |
| RR Lacertae | 37.5 | +55 55 | 8.5— 9.2 | 6 10.1 | 4 18; | 11 4; | 17 14; | 24 0 | | | | |
| V Lacertae | 22 44.5 | +55 48 | 8.5— 9.5 | 4 23.6 | 3 2; | 13 1; | 23 0; | 27 23 | | | | |
| SW Cassiop. | 23 03.7 | +58 11 | 9.2— 9.7 | 5 10.6 | 5 3; | 10 13; | 21 11; | 26 21 | | | | |
| RS Cassiop. | 32.6 | +61 52 | 9.0—11.0 | 6 07.1 | 2 14; | 8 21; | 21 11; | 27 18 | | | | |
| RY Cassiop. | 47.2 | +58 11 | 9.3—11.8 | 12 03.4 | 6 7; | 18 11 | | | | | | |
| V Cephei | 23 51.7 | +82 38 | 6.0—7.0 | 0 23.6 | 2 16; | 7 16; | 17 15; | 27 15 | | | | |

## Minima of Variable Stars of Short Period.

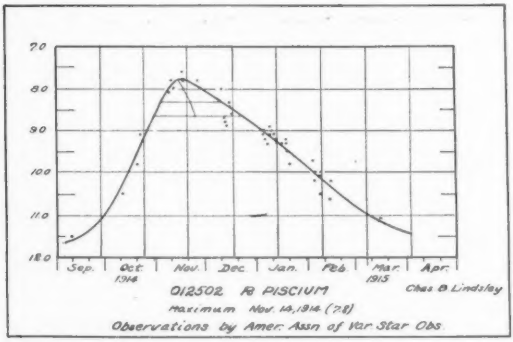
[Calculated by Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

| Star | R. A. 1900 | Decl. 1900 | Magnitude | Approx. Period | Greenwich mean times of minima in 1916 February |
|---|---|---|---|---|---|
| | h m | ° ′ | | d h | d h d h d h d h |
| SY Androm. | 0 08.0 | +43 09 | 9.5—13.0 | 34 21.8 | 9 6 |
| RT Sculptor. | 31.5 | —26 13 | 9.6—10.5 | 0 12.3 | 1 20; 9 12; 17 5; 24 21 |
| UU Androm. | 38.5 | +30 24 | 10.7—11.9 | 1 11.7 | 3 11; 10 21; 18 7; 25 18 |
| U Cephei | 0 53.4 | +81 20 | 7.0— 9.0 | 2 11.8 | 6 16; 14 3; 21 15; 29 2 |
| Z Persei | 2 33.7 | +41 46 | 9.4—12 | 3 01.4 | 6 1; 12 4; 18 6; 24 9 |
| TW Cassiop. | 37.6 | +65 19 | 8.2— 9.0 | 1 10.3 | 3 17; 10 21; 18 0; 25 4 |
| RY Persei | 39.0 | +47 43 | 8.0—10.3 | 6 20.7 | 6 9; 13 6; 20 3; 26 23 |
| RZ Cassiop. | 39.9 | +69 13 | 6.9— 8.1 | 1 04.7 | 6 13; 13 17; 20 21; 28 1 |
| TX Cassiop. | 44.4 | +62 22 | 9.4—10.1 | 2 22.2 | 2 11; 11 6; 20 0; 28 20 |
| ST Persei | 53.7 | +38 47 | 8.5—10.5 | 2 15.6 | 8 22; 16 21; 24 19 |
| RX Cassiop. | 2 58.8 | +67 11 | 8.6— 9.1 | 32 07.6 | 10 6 |
| Algol | 3 01.7 | +40 34 | 2.3— 3.5 | 2 20.8 | 5 12; 11 6; 22 16; 28 9 |
| RT Persei | 16.7 | +46 12 | 9.5—11.5 | 0 20.4 | 6 1; 12 20; 19 15; 26 11 |
| λ Tauri | 55.1 | +12 12 | 3.3— 4.2 | 3 22.9 | 4 2; 11 23; 19 21; 27 19 |
| RW Tauri | 3 57.8 | +27 51 | 7.1—<11 | 2 18.5 | 3 16; 11 23; 20 7; 28 14 |
| RV Persei | 4 04.2 | +33 59 | 9.5—11.0 | 1 23.4 | 1 3; 9 0; 16 22; 24 19 |
| RW Persei | 13.3 | +42 04 | 8.8—11.0 | 15 04.8 | 8 10; 21 15 |
| SZ Tauri | 31.4 | +18 20 | 7.2— 7.7 | 3 03.6 | 5 16; 15 3; 24 13 |
| RS Cephei | 4 48.6 | +80 06 | 9.5—12.0 | 12 10.1 | 9 18; 22 4 |
| TT Aurigae | 5 02.8 | +39 27 | 7.8— 8.7 | 0 16.0 | 4 10; 11 2; 17 18; 24 10 |
| RY Aurigae | 11.5 | +38 13 | 10.7—11.7 | 2 17.5 | 4 23; 10 10; 21 8; 26 19 |
| RZ Aurigae | 42.9 | +31 40 | 10.6—13.3 | 3 00.3 | 6 12; 12 12; 18 13; 24 13 |
| SV Tauri | 45.8 | +28 05 | 9.4—11.0 | 2 04.0 | 8 6; 16 22; 25 14 |
| Z Orionis | 50.2 | +13 40 | 9.7—10.7 | 5 04.9 | 4 2; 14 12; 24 22 |
| SV Gemin. | 54.6 | +24 28 | 9.8—<11 | 4 00.2 | 4 9; 12 9; 20 9; 28 9 |
| RW Gemin. | 5 55.4 | +23 08 | 9.5—11.0 | 2 20.8 | 1 23; 7 16; 18 3; 24 21 |
| U Columbae | 6 11.2 | —33 03 | 9.2—10.0 | 2 19.2 | 4 5; 9 19; 21 0; 26 15 |
| SX Gemin. | 22.0 | +20 37 | 10.8—11.5 | 1 08.8 | 4 12; 12 16; 20 21; 29 2 |
| RW Monoc. | 29.3 | + 8 54 | 9.0—10.8 | 1 21.7 | 4 2; 11 17; 19 8; 26 23 |
| RX Gemin. | 43.6 | +33 21 | 8.8— 9.6 | 12 05.0 | 6 0; 18 5 |
| RU Monoc. | 6 49.4 | — 7 28 | 9.8—10.5 | 0 21.5 | 4 23; 12 3; 19 7; 26 11 |
| R Can. Maj. | 7 14.9 | —16 12 | 5.8— 6.4 | 1 03.3 | 7 12; 16 14; 25 16 |
| RY Gemin. | 21.7 | +15 52 | 8.9—<10 | 9 07.2 | 4 12; 13 19; 23 2 |
| Y Camelop. | 27.6 | +76 17 | 9.5—12 | 3 07.3 | 3 19; 13 17; 23 15 |
| TX Gemin. | 30.3 | +17 8 | 10.0—11.9 | 2 19.2 | 4 10; 12 19; 21 5; 29 14 |
| RR Puppis | 43.5 | —41 08 | 9.4—10.7 | 6 10.3 | 5 0; 11 10; 17 21; 24 7 |
| V Puppis | 7 55.4 | —48 58 | 4.1— 4.8 | 1 10.9 | 3 7; 10 14; 17 20; 25 3 |
| X Carinae | 8 29.1 | —58 53 | 7.9— 8.7 | 0 13.0 | 5 20; 13 23; 22 2 |
| S Cancri | 8 38.2 | +19 24 | 8.2—10 | 9 11.6 | 5 7; 14 18; 24 6 |
| RX Hydrae | 9 00.8 | — 7 52 | 9.1—10.5 | 2 6.8 | 7 1; 16 4; 25 7 |
| S Antliae | 27.9 | —28 11 | 6.7— 7.3 | 0 07.8 | 6 24; 13 11; 19 23; 26 11 |
| S Velorum | 29.4 | —44 46 | 7.8— 9.3 | 5 22.4 | 1 10; 7 8; 19 5; 25 3 |
| Y Leonis | 9 31.1 | +26 41 | 9.3—11.2 | 1 16.5 | 1 18; 10 4; 18 14; 27 1 |
| RR Velorum | 10 17.8 | —41 36 | 10.0—10.9 | 1 20.5 | 5 19; 15 1; 24 8 |
| SS Carinae | 10 54.2 | —61 23 | 12.2—12.8 | 3 07.2 | 6 15; 13 6; 19 20; 26 11 |
| ST Urs. Maj. | 11 22.4 | +45 44 | 6.7— 7.2 | 8 19.2 | 1 10; 10 5; 19 0; 27 19 |
| RW Urs. Maj. | 35.4 | +52 34 | 10.3—11.4 | 7 07.9 | 6 2; 13 10; 20 17; 28 1 |
| Z Draconis | 11 39.8 | +72 49 | 9.9—13.6 | 1 08.6 | 5 21; 12 15; 19 10; 26 5 |
| RZ Centauri | 12 55.6 | —64 05 | 8.5— 8.9 | 1 21.0 | 5 6; 12 18; 20 6; 27 18 |
| RS Can. Ven. | 13 06.3 | +36 28 | 7.5—12.5 | 4 19.2 | 8 0; 17 14; 27 4 |
| SS Centauri | 13 07.2 | —63 37 | 8.8—10.4 | 2 11.5 | 5 6; 12 16; 20 3; 27 13 |
| δ Librae | 14 55.6 | — 8 07 | 4.8— 6.2 | 2 07.9 | 3 8; 10 8; 17 8; 24 7 |

## Minima of Variable Stars of Short Period—Continued.

| Star | R. A. 1900 | Decl. 1900 | Magnitude | Approx. Period | Greenwich mean times of minima in 19 February |
|---|---|---|---|---|---|
| | h m | ° ′ | | d h | d h d h d h d h |
| U Coronae | 15 14.1 | +32 01 | 7.6— 8.7 | 3 10.9 | 3 13; 10 11; 17 8; 24 6 |
| TW Draconis | 32.4 | +64 14 | 7.3— 8.9 | 2 19.4 | 7 22; 16 8; 24 18 |
| SS Librae | 15 43.4 | −15 14 | 9.3—11.5 | 0 18.4 | 8 9; 16 1; 23 16 |
| SW Ophiuchi | 16 11.1 | — 6 44 | 9.2—10.0 | 2 10.7 | 6 17; 14 1; 21 9; 28 17 |
| SX Ophiuchi | 12.6 | — 6 25 | 10.5—11.2 | 2 01.5 | 1 22; 10 4; 18 10; 26 17 |
| R Arae | 31.1 | −56 48 | 6.8— 7.9 | 4 10.2 | 7 20; 16 17; 25 13 |
| TT Herculis | 16 49.9 | +17 00 | 8.9— 9.3 | 20 18.1 | 9 21; 19 13 |
| TU Herculis | 17 09.8 | +30 50 | 9.5—12 | 2 06.4 | 2 19; 9 14; 23 5; 30 0 |
| U Ophiuchi | 11.5 | + 1 19 | 6.0— 6.7 | 0 20.1 | 2 15; 11 1; 19 10; 27 19 |
| *u* Herculis | 13.6 | +33 12 | 4.6— 5.4 | 2 01.2 | 2 21; 9 1; 21 8; 27 12 |
| TX Herculis | 15.4 | +42 00 | 8.3— 9.0 | 1 00.7 | 5 12; 12 17; 19 22; 27 3 |
| RV Ophiuchi | 29.8 | + 7 19 | 9. —12 | 3 16.5 | 2 15; 10 0; 17 9; 24 18 |
| SZ Herculis | 36.0 | +33 01 | 9.5—10.3 | 0 19.6 | 6 10; 14 14; 22 18 |
| TX Scorpii | 48.6 | −34 13 | 7.5— 8.2 | 0 22.6 | 5 8; 12 21; 20 10; 27 23 |
| UX Herculis | 49.7 | +16 57 | 8.8—10.5 | 1 13.2 | 6 6; 13 23; 21 17; 29 11 |
| Z Herculis | 53.6 | +15 09 | 7.1— 7.9 | 3 23.8 | 6 4; 14 4; 22 4 |
| WX Sagittae | 53.6 | −17 24 | 9.2—10.8 | 2 03.1 | 7 15; 16 4; 24 16 |
| WY Sagittae | 17 54.9 | −23 1 | 9.5—10.6 | 4 16.0 | 6 14; 15 22; 25 6; |
| SX Draconis | 18 03.0 | +58 23 | 9.3—10.5 | 5 04.1 | 1 19; 12 4; 22 12 |
| RS Sagittarii | 11.0 | −34 08 | 5.9— 6.3 | 2 10.0 | 6 12; 13 18; 21 0; 28 6 |
| V Serpentis | 11.1 | −15 34 | 9.5—11.1 | 3 10.9 | 7 21; 14 18; 21 16; 28 14 |
| RZ Scuti | 21.1 | — 9 15 | 7.4— 8.3 | 15 03.2 | 1 9; 16 12 |
| RZ Draconis | 21.8 | +58 50 | 9.5—10.2 | 0 13.2 | 3 0; 11 6; 19 13; 27 19 |
| RX Herculis | 26.0 | +12 32 | 7.0— 7.6 | 0 21.3 | 4 6; 13 4; 22 1 |
| SX Sagittarii | 39.7 | −30 36 | 8.7— 9.8 | 2 01.8 | 3 15; 11 22; 20 5; 28 13 |
| RR Draconis | 40.8 | +62 34 | 9.3—13 | 2 19.9 | 5 12; 13 23; 22 10 |
| RS Scuti | 43.7 | −10 21 | 9.3—10.3 | 0 15.9 | 4 12; 11 3; 17 19; 24 10 |
| *β* Lyrae | 46.4 | +33 15 | 3.4— 4.1 | 12 21.8 | 1 15; 14 13; 27 11 |
| U Scuti | 18 48.9 | −12 44 | 9.1— 9.6 | 0 22.9 | 10 0; 19 13; 29 2 |
| RX Draconis | 19 01.1 | +58 35 | 9.3—10.2 | 1 21.4 | 2 21; 10 11; 18 0; 25 14 |
| RV Lyrae | 12.5 | +32 15 | 11. —12.8 | 3 14.4 | 11 13; 18 18; 25 23 |
| RS Vulpec. | 13.4 | +22 16 | 6.9— 8.0 | 4 11.4 | 7 20; 16 19; 25 18 |
| U Sagittae | 14.4 | +19 26 | 6.5— 9.0 | 3 09.1 | 5 19; 12 13; 19 7; 26 2 |
| Z Vulpec. | 17.5 | +25 23 | 7.3— 8.5 | 2 10.9 | 8 7; 15 16; 23 0 |
| TT Lyrae | 24.3 | +41 30 | 9.3—11.6 | 5 05.8 | 3 5; 13 16; 24 4; 29 10 |
| UZ Draconis | 26.1 | +68 44 | 9.0— 9.8 | 1 15.1 | 6 2; 12 14; 19 3; 25 16 |
| SY Cygni | 19 42.7 | +32 28 | 10 —12 | 6 00.2 | 3 9; 10 9; 22 9; 28 10 |
| WW Cygni | 20 00.6 | +41 18 | 9.3—13.4 | 3 07.6 | 2 5; 9 20; 16 11; 24 2 |
| SW Cygni | 03.8 | +46 01 | 9. —11.7 | 4 13.8 | 3 11; 12 15; 21 18 |
| VW Cygni | 11.4 | +34 12 | 9.8—11.8 | 8 10.3 | 7 0; 15 10; 23 21 |
| RW Capric. | 12.2 | −17 59 | 8.8—10.6 | 3 09.4 | 4 18; 11 13; 18 7; 25 2 |
| UW Cygni | 19.6 | +42 55 | 10.5—13 | 3 10.8 | 7 9; 14 7; 21 4; 28 2 |
| V Vulpec. | 32.3 | +26 15 | 8.2—9.8 | 37 19.0 | 14 10; |
| W Delphini | 33.1 | +17 56 | 9.4—12.1 | 4 19.4 | 9 22; 19 13; 29 4 |
| RR Delphini | 38.9 | +13 35 | 10.5—11.8 | 4 14.4 | 4 0; 13 4; 22 9 |
| Y Cygni | 48.1 | +34 17 | 7.1— 7.9 | 1 12.0 | 7 16; 15 4; 22 15 |
| WZ Cygni | 49.3 | +38 27 | 9.9—10.8 | 0 14.0 | 4 2; 9 22; 21 15; 27 11 |
| RR Vulpec. | 20 50.5 | +27 32 | 9.6—11.0 | 5 01.2 | 9 11; 19 13; 29 16 |
| VV Cygni | 21 02.3 | +45 23 | 12.1—13.8 | 1 11.4 | 2 18; 10 3; 17 12; 24 21 |
| AE Cygni | 09.0 | +30 20 | 10.8—11.4 | 0 23.3 | 5 7; 15 0; 24 16 |
| RY Aquarii | 14.8 | −11 14 | 8.8—10.4 | 1 23.2 | 3 2; 10 22; 18 19; 26 16 |
| UZ Cygni | 55.2 | +43 52 | 8.9—11.6 | 31 07.3 | 14 22 |
| RT Lacertae | 21 57.4 | +43 24 | 9.1—10.5 | 5 01.7 | 1 13; 11 17; 21 20 |
| RW Lacertae | 22 40.6 | +49 08 | 10.2—11.2 | 5 04.4 | 3 6; 13 14; 24 0; 29 4 |
| X Lacertae | 22 45.0 | +55 54 | 8.2— 8.6 | 5 10.6 | 2 0; 12 21; 23 18; 29 5 |
| TT Androm. | 23 08.7 | +45 36 | 11.3—12.6 | 2 18.3 | 4 15; 12 23; 21 6; 29 14 |
| Y Piscium | 29.3 | + 7 22 | 9.0—12.0 | 3 18.4 | 3 9; 11 21; 19 10; 26 23 |
| TW Androm. | 23 58.2 | +32 17 | 8.6—11.5 | 4 02.9 | 2 9; 10 15; 18 21; 27 3 |


7.0
8.0
9.0
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Sep.
Oct.
1914
Nov.
Dec.
Jan.
Feb.
Mar.
1915
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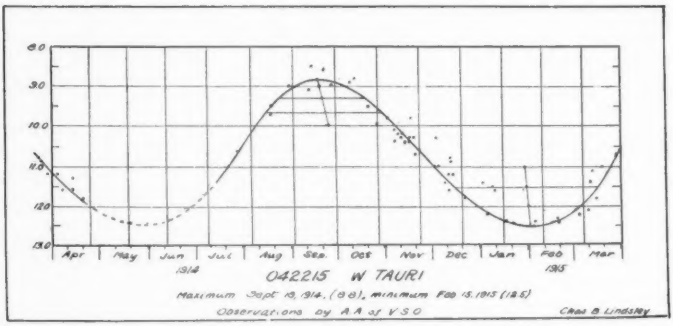
012502 R PISCIUM
Chas. B. Lindsley
Maximum Nov. 14, 1914. (7.8)
Observations by Amer. Assn of Var. Star Obs.


8.0
9.0
10.0
11.0
12.0
13.0
Apr.
May
Jun.
1914
Jul.
Aug.
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Oct.
Nov.
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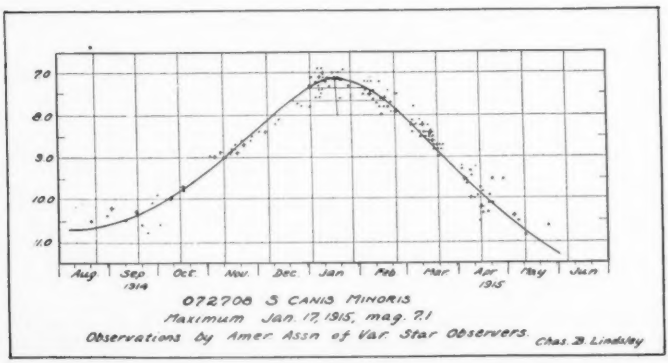
Feb.
1915
Mar.
042215 W TAURI
Maximum Sept. 13, 1914. (8.8), minimum Feb. 15, 1915 (12.5)
Observations by A.A.o.f. V.S.O.
Chas. B. Lindsley


7.0
8.0
9.0
10.0
11.0
Aug.
Sep.
1914
Oct.
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Apr.
1915
May
Jun.
072708 S CANIS MINORIS
Maximum Jan. 17, 1915, mag. 7.1
Observations by Amer. Assn of Var. Star Observers.
Chas. B. Lindsley

## NOTES FOR OBSERVERS.

### Monthly Report of the American Association of Variable Star Observers, Nov.-Dec., 1915.

We welcome as new members of the Association this month.

Mr. Charles L. Whitehorn, "Wh" Bloomfield, N. J. and

Dr. Edward F. Bigelow, "Bi" Sound Beach, Conn.

The latter observes with a 6″ refractor and should be able to do valuable work with it in observing the faint variables.

Mr. Bancroft leads this month in the number of observations contributed. His list contained 157 observations of 102 variables, a fine record. In this extension of the work, to cover many variables each month, a higher degree of efficiency is attained. Two observations a month of a large number of different stars are much more desirable than frequent observations of a few selected variables.

The secretary observed the asteroid "Cleopatra" on the field of the variable 045307 R Orionis on the night of December 3. Photographs promptly taken at the H. C. O. revealed the identity of the object. For the benefit of those who may have a like experience, the following advice may be of service: The first step is to ascertain if the unidentified object is in motion. This is done by noting a change in the configuration of the star field, or by taking transits of the object and of an adjacent star over a wire placed in the field. If no motion is detected the object is doubtless a nova or a variable, and the nearest observatory should be notified immediately. In this case, although the observation was disappointing to a certain degree, it lends zest to the work in which we are engaged, and shows that we must be ever on the alert.

The event of the month in the life of the Association was the meeting in Boston, Mass., November 20, 21, a red letter occasion for all of our members who participated.

At the invitation of Professor E. C. Pickering, Director of the Harvard College Observatory, the members met at the Observatory on the evening of November 20, where we were cordially welcomed by the Director, Professor Bailey, Mr. Leon Campbell, and Miss Woods.

Professor Bailey described the work on the cluster variables on which he is engaged, and Mr. Campbell escorted us about the Observatory, explaining the details of the variable star records which he faithfully keeps, and the interesting instrumental equipment of the observatory. Ample opportunity was offered for observing with the historic 15″ equatorial and the 12″ coudé. Many interesting objects were observed, and the evening was thoroughly enjoyed.

On the afternoon of the 21st we were again invited to the Observatory, a group picture was taken, and the members had the pleasure of meeting Miss Annie J. Cannon, who explained most interestingly the great work of the classification of stellar spectra in which she is engaged. We also enjoyed seeing the splendid set of illuminated plates on exhibition at the Observatory, and many other features of interest.

Later, the party adjourned to the Copley Square Hotel where a banquet was served. Professor Pickering and Mr. Campbell were our guests, and the evening was enjoyably spent in discussing our work in general, and plans were perfected for increasing the efficiency of our service.

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1915.

*001032*
S Sculptoris

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 3 | 9.7 | Ba |
| | 10 | 9.5 | R |
| | 11 | 9.5 | Ba |
| | 22 | 8.8 | Ba |

001726
T Androm.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 8.8 | O |
| | 6 | 9.2 | Pi |
| | 7 | 8.8 | O |
| | 8 | 8.5 | Ly |
| | 10 | 8.9 | R |
| | 12 | 8.7 | Ly |
| | 22 | 8.8 | Ba |
| | 25 | 9.2 | O |
| | 25 | 9.3 | Bu |
| | 28 | 9.3 | Sp |
| | 28 | 9.3 | O |
| | 30 | 9.7 | S |
| 12 | 5 | 9.6 | O |

001755
T Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 9.6 | Bu |
| | 6 | 10.2 | Pi |
| | 7 | 10.5 | Sp |
| | 28 | 8.7 | Sp |
| | 30 | 9.2 | O |

001838
R Androm.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 6 | 12.9 | Hu |

*001909*
S Ceti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 8.1 | R |
| | 22 | 8.0 | Ba |
| | 25 | 8.4 | Bu |
| | 28 | 8.3 | Sp |
| | 29 | 8.5 | Pi |
| | 30 | 8.5 | O |
| 12 | 2 | 8.5 | S |
| | 3 | 8.5 | O |
| | 3 | 8.5 | Cr |
| | 7 | 8.5 | O |

002614
T Piscium

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 12 | 9.4 | M |

003179
Y Cephei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 7 | 11.6 | Hu |
| | 22 | 10.0 | Ba |
| | 27 | 10.1 | Pi |

004047
U Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 8.5 | Bu |
| | 6 | 8.4 | Pi |
| | 10 | 7.9 | R |
| | 27 | 8.4 | Ba |
| | 30 | 9.5 | S |

004435
V Androm.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 11.0 | O |
| | 6 | 10.5 | Pi |
| | 6 | 10.9 | Hu |
| | 7 | 10.7 | O |
| | 22 | 9.4 | Ba |
| | 25 | 10.0 | Bu |
| | 25 | 9.8 | O |
| | 28 | 9.7 | O |
| 12 | 5 | 9.5 | O |

004533
RR Androm.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 9.8 | O |
| | 6 | 10.2 | Hu |
| | 7 | 9.6 | O |
| | 22 | 10.5 | Ba |
| | 25 | 10.8 | O |
| | 25 | 8.7 | Bu |

004746
RV Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 9.3 | Bu |
| | 6 | 9.9 | Pi |
| | 27 | 11.1 | Ba |

004958
W Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 11.0 | Bu |
| | 7 | 11.9 | Nt |
| | 27 | 11.2 | Ba |
| | 28 | 11.6 | Sp |

*010102*
Z Ceti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 7 | 12.0 | Ho |
| | 26 | 13.0 | Ba |

010940
U Androm.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 26 | 10.7 | Ba |

011272
S Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 26 | 12.4 | Nt |

011208
S Piscium

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 25 | 10.0 | O |
| | 26 | 10.3 | Ba |
| | 28 | 10.0 | O |
| 12 | 1 | 9.4 | Y |
| | 5 | 9.8 | O |

011712
U Piscium

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 26 | 12.4 | Ba |

012350
RZ Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | | | |
| 11 | 10 | 12.8 | Y |

012502
R Piscium

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 9.0 | Sp |
| | 7 | 9.0 | Pi |
| | 10 | 8.8 | R |
| | 25 | 9.0 | O |
| | 26 | 8.8 | Ba |
| | 27 | 9.1 | Pi |
| | 28 | 9.0 | Sp |
| 12 | 5 | 9.1 | O |

013238
RU Androm.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 3 | 10.2 | O |
| | 6 | 10.0 | Pi |
| | 9 | 10.6 | M |
| | 10 | 10.7 | R |
| | 10 | 10.5 | Y |
| | 28 | 10.4 | O |

013338
Y Androm.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 3 | 10.0 | O |
| | 9 | 10.4 | M |
| | 10 | 10.3 | Hu |
| | 10 | 9.9 | R |
| | 27 | 10.8 | Ba |
| | 28 | 10.6 | O |

014958
X Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 10.9 | Pi |
| | 10 | 12.0 | Y |
| | 26 | 11.3 | Pi |
| | 27 | 12.0 | Ba |
| | 28 | 12.0 | Sp |

015254
U Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 8.5 | Bu |
| | 6 | 8.4 | Ly |
| | 11 | 8.4 | R |
| | 12 | 8.3 | Ly |
| | 20 | 8.4 | Ly |
| | 27 | 8.2 | Ba |
| | 28 | 8.6 | Pi |
| | 28 | 8.5 | Sp |
| | 30 | 8.6 | O |
| 12 | 7 | 8.5 | O |

021024
R Arietis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 10.2 | Bu |
| | 6 | 10.2 | Pi |
| | 6 | 10.4 | Ly |
| | 10 | 10.4 | Pi |
| | 27 | 12.2 | Ba |

*021403*
*o* Ceti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 29 | 7.5 | Ho |
| 11 | 29 | 7.4 | E |

*o* Ceti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 7.3 | Nt |
| | 5 | 6.8 | Ma |
| | 6 | 6.9 | Ly |
| | 6 | 6.9 | Pi |
| | 6 | 7.3 | Nt |
| | 6 | 6.6 | Bu |
| | 7 | 6.5 | Ma |
| | 7 | 6.5 | Hu |
| | 7 | 6.8 | Ho |
| | 9 | 7.2 | Nt |
| | 9 | 6.6 | Ma |
| | 10 | 6.6 | E |
| | 10 | 6.7 | Pi |
| | 11 | 6.8 | R |
| | 12 | 6.5 | Ly |
| | 13 | 6.7 | Nt |
| | 16 | 6.2 | Nt |
| | 23 | 4.3 | Nt |
| | 24 | 4.6 | Mu |
| | 25 | 4.2 | Nt |
| | 25 | 4.4 | Ma |
| | 25 | 4.5 | Mu |
| | 25 | 4.7 | Bu |
| | 26 | 4.3 | Hu |
| | 26 | 4.1 | Mu |
| | 27 | 4.0 | Pi |
| | 27 | 3.7 | Ba |
| | 28 | 4.2 | Nt |
| | 28 | 4.0 | O |
| | 30 | 3.9 | Nt |
| | 30 | 4.1 | O |
| 12 | 3 | 4.0 | O |
| | 3 | 3.7 | Cr |
| | 5 | 3.8 | O |
| | 7 | 3.6 | O |

021656
S Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 9.4 | Bu |
| | 8 | 9.5 | Ly |
| | 9 | 9.4 | Pi |
| | 11 | 8.7 | R |
| | 26 | 9.2 | Pi |
| | 27 | 8.5 | Ba |
| | 28 | 8.7 | Sp |

*022000*
R Ceti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 27 | 11.4 | Ba |
| 12 | 1 | 10.6 | Y |

022150
RR Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 10.6 | Y |
| 12 | 1 | 11.3 | Y |

*022813*
U Ceti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 7.9 | Nt |
| | 7 | 8.2 | Ma |

U Ceti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 7 | 7.7 | Ho |
| | 11 | 8.8 | R |
| | 25 | 8.8 | Bu |
| | 26 | 8.4 | Ba |
| | 30 | 8.9 | Pi |

023133
R Triang.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 10.6 | O |
| | 10 | 10.9 | Hu |
| | 27 | 10.4 | Ba |
| | 28 | 10.0 | Sp |

024356
W Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 9.8 | Bu |
| | 6 | 9.6 | Hu |
| | 8 | 9.6 | Ly |
| | 9 | 10.3 | Pi |
| | 11 | 10.4 | R |
| | 26 | 10.3 | Pi |
| | 27 | 10.3 | Ba |

030514
U Arietis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 26 | 12.0 | B |

*031401*
X Ceti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 7 | 8.8 | Hu |
| | 27 | 9.0 | Pi |
| | 30 | 9.0 | Pi |
| | 30 | 8.8 | O |

032043
Y Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 9.4 | Ma |
| | 4 | 9.4 | Bu |
| | 6 | 8.9 | Hu |
| | 7 | 9.7 | Ma |
| | 8 | 9.4 | Ly |
| | 9 | 9.7 | Pi |
| | 11 | 10.0 | R |
| | 27 | 9.7 | Ba |
| | 30 | 9.8 | O |

032335
R Persei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 9.4 | Bu |
| | 9 | 9.1 | Pi |
| | 11 | 9.1 | R |
| | 27 | 9.8 | Ba |

033362
U Camelop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 9.0 | Ma |
| | 7 | 8.9 | Ma |
| | 11 | 8.9 | R |
| | 30 | 8.6 | Pi |

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1915—Continued.

*035124*
T Eridani

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 3 | 11.7 | Ho |

*035915*
V Eridan

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 29 | 8.3 | Ho |
| 11 | 1 | 8.2 | Pi |
| | 7 | 8.1 | Ho |
| | 26 | 8.3 | Ba |
| | 30 | 8.7 | Pi |

042215
W Tauri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 6 | 11.7 | Ly |
| | 10 | 12.6 | Hu |
| | 12 | 11.6 | Ly |
| | 20 | 11.4 | Ly |
| | 27 | 10.9 | Ly |
| | 27 | 12.1 | Ba |
| | 30 | 12.2 | Nt |

042209
R Tauri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 14 | 12.9 | Sp |

042309
S Tauri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 13 | 13.4 | Sp |

043065
T Camelop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 13.5 | Y |

043208
RX Tauri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 9 | 10.2 | Pi |
| | 10 | 9.3 | Hu |
| | 26 | 8.6 | Ba |
| | 27 | 9.0 | Pi |
| 12 | 1 | 9.1 | Y |
| | 3 | 9.0 | O |

043274
X Camelop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 8.2 | Bu |
| | 2 | 8.2 | O |
| | 2 | 8.1 | Sp |
| | 6 | 8.3 | Pi |
| | 7 | 8.0 | O |
| | 8 | 8.1 | Ly |
| | 9 | 8.4 | Pi |
| | 11 | 7.9 | R |
| | 12 | 8.2 | Ly |
| | 25 | 8.9 | O |
| | 25 | 8.8 | Pi |
| | 28 | 9.0 | O |
| | 30 | 8.8 | Nt |
| | 30 | 9.1 | Pi |
| 12 | 3 | 9.3 | O |
| | 5 | 9.0 | O |
| | 7 | 9.9 | O |

044617
V Tauri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 28 | 10.5 | O |
| | 30 | 10.2 | Nt |
| 12 | 1 | 10.2 | Y |

*045514*
R Leporis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 29 | 6.5 | Hu |
| 11 | 1 | 7.5 | Pi |
| | 2 | 8.0 | M |
| | 7 | 7.0 | Ho |
| | 14 | 7.3 | Ho |
| | 26 | 6.9 | Ba |

*050022*
T Leporis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 29 | 9.9 | Ho |
| 11 | 1 | 10.2 | Pi |
| | 7 | 9.6 | Ho |

050953
R Aurigae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 12.5 | Sp |

052034
S Aurigae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 6 | 9.3 | Pi |
| | 10 | 9.4 | Pi |
| | 30 | 9.3 | Pi |

052036
W Aurigae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 28 | 13.0 | B |
| | 30 | 11.1 | Pi |

*052405*
S Orionis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 8.1 | M |
| | 2 | 8.2 | Bu |
| | 3 | 8.2 | Ho |
| | 12 | 8.3 | M |
| | 14 | 8.0 | Ho |
| | 27 | 8.1 | Ba |
| | 29 | 8.6 | M |

053068
S Camelop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 8.6 | Y |

*053005*
T Orionis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 10.0 | M |
| | 2 | 9.8 | Bu |
| | 3 | 9.7 | Ho |
| | 9 | 9.7 | Pi |
| | 12 | 9.5 | M |
| | 13 | 9.1 | Ho |
| | 13 | 9.7 | Pi |
| | 14 | 9.8 | Sp |
| | 27 | 10.4 | Ba |

053531
U Aurigae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 27 | 12.8 | Ba |
| | 28 | 12.9 | B |
| | 30 | 11.4 | Pi |
| 12 | 1 | 13.0 | ± Y |

054319
SU Tauri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 12 | 1 | 9.4 | Y |

054920
U Orionis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 9.8 | M |
| | 9 | 10.4 | Pi |
| | 27 | 10.5 | Ba |
| | 29 | 10.0 | M |

054974
V Camelop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 26 | 11.4 | B |
| | 26 | 11.5 | Ba |
| | 27 | 11.3 | Ba |
| | 28 | 11.0 | O |
| | 29 | 11.4 | M |
| | 30 | 11.1 | Pi |
| 12 | 3 | 10.5 | O |
| | 5 | 9.7 | O |

055353
Z Aurigae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 7 | 10.6 | Pi |

*060224*
S Leporis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 3 | 6.2 | Ho |

060450
X Aurigae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 7 | 10.2 | Pi |
| | 26 | 8.9 | Ba |
| | 28 | 8.8 | B |
| | 30 | 8.8 | Pi |

*061702*
V Monoc.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 29 | 10.8 | Ho |
| 11 | 7 | 10.7 | Ho |
| | 13 | 10.7 | Pi |
| | 27 | 8.9 | Ba |

063159
U Lyncis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 13.1 | Y |
| | 27 | 13.5 | Ba |

063558
S Lyncis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 12.0 | Pi |
| | 2 | 11.7 | Sp |
| | 10 | 11.2 | Y |
| | 13 | 11.4 | Sp |
| | 27 | 10.1 | Ba |
| | 28 | 10.2 | O |
| 12 | 5 | 9.9 | O |

*065208*
X Monoc.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 29 | 7.8 | Ho |
| 11 | 7 | 7.6 | Ho |
| | 13 | 7.4 | Pi |

065820
TW Gemin.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 8.1 | Pi |
| | 2 | 8.3 | M |
| | 30 | 8.3 | Nt |
| | 30 | 8.4 | Pi |

070122 a
R Gemin.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 7.0 | Pi |
| | 2 | 7.4 | M |
| | 30 | 8.3 | Nt |
| | 30 | 7.7 | Pi |

070122
Z Gemin.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 12.3 | M |
| | 30 | 12.5 | Nt |

070310
R Can. Min.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 13 | 9.5 | Pi |

072708
S Can. Min.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 31 | 9.4 | M |
| 11 | 8 | 8.8 | Ly |
| | 12 | 8.8 | M |
| | 13 | 8.7 | Pi |
| | 20 | 8.6 | Ly |
| | 27 | 7.9 | Ba |
| | 29 | 8.2 | M |

072811
T Can. Min.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 14 | 10.0 | Sp |

073508
U Can. Min.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 27 | 9.5 | Ba |

073722
S Gemin.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 10.8 | M |

074322
T Gemin.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 8.7 | Pi |
| | 2 | 8.8 | M |
| | 30 | 9.2 | Pi |

*075813*
U Puppis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 3 | 12.2 | Ho |

081112
R Cancri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 10.9 | E |

*082405*
RT Hydre

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 3 | 8.4 | Ho |

083019
U Cancri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 14 | 10.1 | Sp |

084838
S Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 10.0 | E |
| | 14 | 8.8 | Sp |

*085008*
T Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 9.0 | E |

090151
V Urs. Maj.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 10.5 | Pi |
| | 13 | 11.0 | Pi |
| | 27 | 11.0 | Ba |

090425
W Cancri

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 14 | 12.8 | Sp |

*093014*
X Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 12.7 | E |

093178
Y Draconis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 13.2 | Y |

094211
R Leonis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 5.5 | E |
| | 2 | 5.8 | M |
| | 12 | 5.6 | M |

*094622*
Y Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 3 | 6.4 | Ho |

095421
V Leonis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 14 | 9.3 | Sp |

103769
R Urs. Maj.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 8 | 10.5 | Ly |
| | 11 | 9.0 | Ba |
| | 12 | 8.9 | M |
| | 12 | 10.1 | Ly |
| | 13 | 8.8 | Pi |
| | 20 | 9.0 | Ly |
| | 20 | 8.0 | Ba |
| | 26 | 7.7 | Ba |
| | 29 | 8.0 | M |

*104620*
V Hydrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 3 | 6.9 | Ho |

123160
T Urs. Maj.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 29 | 8.5 | E |
| 11 | 1 | 8.5 | E |
| | 6 | 8.6 | Nt |
| | 6 | 8.5 | Ly |
| | 11 | 8.5 | Ba |
| | 12 | 8.7 | Ly |

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1915—Continued.

T Urs. Maj.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 20 | 8.9 | Ly |
| | 20 | 9.3 | Ba |
| | 27 | 9.3 | Ly |
| | 28 | 9.5 | Ba |
| | 29 | 9.7 | M |

123459
RS Urs. Maj.

| | | | |
|---|---|---|---|
| 11 | 28 | 10.8 | Ba |

123961
S Urs. Maj.

| | | | |
|---|---|---|---|
| 10 | 29 | 10.4 | E |
| 11 | 1 | 10.2 | E |
| | 6 | 9.7 | Nt |
| | 11 | 9.5 | Ba |
| | 15 | 9.0 | M |
| | 20 | 8.9 | Ba |
| | 28 | 8.6 | Ba |
| | 29 | 8.8 | M |

133273
T Urs. Min.

| | | | |
|---|---|---|---|
| 11 | 11 | 10.6 | Ba |

134440
R Can. Ven.

| | | | |
|---|---|---|---|
| 11 | 1 | 9.5 | E |

141567
U Urs. Min.

| | | | |
|---|---|---|---|
| 11 | 8 | 8.8 | Ly |
| | 11 | 8.8 | Ba |
| | 12 | 8.7 | M |
| | 20 | 8.6 | Ly |
| | 20 | 8.2 | Ba |
| | 27 | 8.0 | Ba |

141954
S Bootis

| | | | |
|---|---|---|---|
| 11 | 6 | 9.5 | Nt |

142584
R Camelop.

| | | | |
|---|---|---|---|
| 11 | 1 | 9.9 | R |
| | 2 | 10.3 | O |
| | 7 | 10.3 | O |
| | 8 | 10.2 | Ly |
| | 12 | 11.0 | R |
| | 20 | 10.6 | Ly |
| | 28 | 10.8 | Ba |

153378
S Urs. Min.

| | | | |
|---|---|---|---|
| 11 | 8 | 11.4 | Ly |
| | 11 | 11.3 | Ba |
| | 12 | 11.2 | M |
| | 12 | 11.5 | Ly |
| | 20 | 11.5 | Ly |
| | 20 | 11.8 | Ba |
| | 25 | 11.6 | Pi |
| | 28 | 12.2 | Ba |

154428
R Cor. Bor.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 25.5 | 6.4 | Mu |
| | 26.5 | 6.6 | Mu |
| | 29.5 | 6.5 | Mu |
| 11 | 2.5 | 6.3 | Nt |
| | 6.5 | 6.2 | Nt |
| | 7.5 | 6.3 | Nt |
| | 7.6 | 6.7 | Mu |
| | 9. | 6.0 | Ph |
| | 10.5 | 6.6 | Mu |
| | 13 | 6.5 | Ph |
| | 13.5 | 6.5 | Nt |
| | 17.5 | 6.5 | Nt |
| | 21.4 | 6.0 | Ba |
| | 30.5 | 6.3 | Nt |

155847
X Herculis

| | | | |
|---|---|---|---|
| 11 | 6 | 6.6 | Nt |
| | 9 | 6.5 | Nt |
| | 17 | 6.4 | Nt |
| | 30 | 6.5 | Nt |

160118
R Herculis

| | | | |
|---|---|---|---|
| 11 | 4 | 13.0 | Hr |

161138
W Cor. Bor.

| | | | |
|---|---|---|---|
| 11 | 21 | 8.7 | Ba |

162807
SS Herculis

| | | | |
|---|---|---|---|
| 11 | 6 | 10.0 | Nt |

163172
R Urs. Min.

| | | | |
|---|---|---|---|
| 11 | 1 | 9.5 | E |
| | 1 | 9.5 | R |
| | 4 | 9.0 | Hr |
| | 11 | 9.3 | Ba |
| | 12 | 9.5 | R |
| | 12 | 9.9 | M |
| | 12 | 8.9 | Ly |
| | 15 | 9.5 | Hr |
| | 20 | 9.5 | Ba |
| | 25 | 10.2 | Pi |
| | 28 | 9.5 | Ba |

163266
R Draconis

| | | | |
|---|---|---|---|
| 10 | 30 | 10.8 | E |
| 11 | 8 | 10.9 | Ly |
| | 11 | 10.9 | M |
| | 11 | 11.2 | Ba |
| | 20 | 11.5 | Ba |
| | 28 | 11.6 | Ba |
| 12 | 3 | 11.8 | Cr |

164055
S Draconis

| | | | |
|---|---|---|---|
| 11 | 1 | 9.3 | R |
| | 11 | 8.6 | M |
| | 12 | 9.0 | R |

171723
RS Herculis

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 8.3 | R |
| | 12 | 9.1 | R |
| | 21 | 9.0 | Ba |
| | 28 | 9.6 | Bu |

172809
RU Ophiuchi

| | | | |
|---|---|---|---|
| 11 | 1 | 8.5 | M |

175458
T Draconis

| | | | |
|---|---|---|---|
| 11 | 11 | 9.8 | M |
| | 11 | 9.8 | Ba |
| | 26 | 10.1 | Y |
| | 28 | 10.3 | Pi |
| | 28 | 10.6 | Ba |

175519
RY Herculis

| | | | |
|---|---|---|---|
| 10 | 30 | 13.0 | E |
| 11 | 26 | 11.2 | Y |

180565
W Draconis

| | | | |
|---|---|---|---|
| 11 | 10 | 11.8 | Y |
| | 11 | 11.8 | M |
| | 26 | 10.1 | Y |
| | 28 | 9.8 | Pi |
| | 28 | 10.4 | Ba |

180531
T Herculis

| | | | |
|---|---|---|---|
| 11 | 5 | 11.9 | Hu |
| | 6 | 9.9 | Bu |

180666
X Draconis

| | | | |
|---|---|---|---|
| 11 | 11 | 10.8 | M |

181136
W Lyrae

| | | | |
|---|---|---|---|
| 11 | 5 | 12.6 | Hu |
| | 6 | 12.1 | B |
| | 25 | 12.4 | B |

182224
SV Herculis

| | | | |
|---|---|---|---|
| 11 | 3 | 9.6 | B |

183308
X Ophiuchi

| | | | |
|---|---|---|---|
| 11 | 1 | 7.2 | R |
| | 1 | 7.3 | M |
| | 4 | 7.8 | Hr |
| | 6 | 7.5 | Ma |
| | 11 | 6.9 | Ba |
| | 12 | 7.7 | R |
| | 15 | 7.4 | Hr |
| | 17 | 7.8 | Ma |
| | 20 | 7.1 | Ba |
| | 25 | 8.0 | Ma |
| | 28 | 7.4 | Ba |
| | 28 | 8.2 | Bu |

*184205*
R Scuti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 24.6 | 6.0 | Mu |
| | 25.5 | 5.9 | Mu |
| | 26.5 | 6.0 | Mu |
| | 29.5 | 6.1 | Mu |
| | 30.5 | 5.8 | Ma |
| 11 | 1.6 | 5.2 | R |
| | 1.6 | 5.8 | Mu |
| | 2.5 | 5.7 | Nt |
| | 3.6 | 5.7 | Mu |
| | 4.6 | 5.3 | R |
| | 5.5 | 5.5 | Ma |
| | 5.6 | 5.8 | Mu |
| | 6.5 | 5.7 | Ma |
| | 6.6 | 5.9 | Mu |
| | 6.6 | 5.8 | Nt |
| | 7.4 | 6.0 | Hu |
| | 7.4 | 5.2 | Pi |
| | 7.5 | 5.6 | Ma |
| | 7.6 | 5.6 | Mu |
| | 9 | 5.2 | Ph |
| | 9.5 | 5.7 | Nt |
| | 10.5 | 5.2 | Mu |
| | 10.6 | 4.3 | R |
| | 11.5 | 5.6 | Ba |
| | 11.6 | 4.1 | R |
| | 12.6 | 4.7 | R |
| | 13 | 5.0 | Ph |
| | 13.5 | 5.6 | Nt |
| | 18.5 | 5.7 | Nt |
| | 20.4 | 5.2 | Ba |
| | 25.5 | 4.8 | Mu |
| | 25.5 | 5.1 | Ma |
| | 28 | 5.8 | Ph |
| | 28.4 | 5.3 | Ba |
| | 28.4 | 5.0 | Bu |
| | 30.5 | 5.4 | Nt |

184243
RW Lyrae

| | | | |
|---|---|---|---|
| 11 | 2 | 11.5 | B |
| | 11 | 11.8 | Ba |
| | 20 | 11.6 | Ba |
| | 25 | 11.4 | B |
| | 26 | 11.7 | Ba |

185243
R Lyrae

| | | | |
|---|---|---|---|
| 11 | 1.7 | 4.1 | R |
| | 12.6 | 3.9 | R |

190108
R Aquilae

| | | | |
|---|---|---|---|
| 11 | 1 | 7.7 | M |
| | 4 | 7.1 | R |
| | 9 | 7.6 | M |
| | 11 | 7.5 | Bu |
| | 12 | 8.2 | R |
| | 20 | 7.5 | Ba |

190967
U Draconis

| | | | |
|---|---|---|---|
| 11 | 7 | 12.0 | Hu |

190926
X Lyrae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 9.3 | M |
| | 1 | 8.6 | R |
| | 6 | 9.1 | Ma |
| | 8 | 8.9 | Ly |
| | 11 | 9.4 | Bu |
| | 20 | 9.0 | Ba |

*191033*
RY Sagittarii

| | | | |
|---|---|---|---|
| 11 | 1 | 6.7 | R |
| | 4 | 6.2 | R |
| | 10 | 6.7 | R |
| | 11 | 6.7 | R |
| | 12 | 6.7 | R |

191637
U Lyrae

| | | | |
|---|---|---|---|
| 11 | 28 | 12.5 | Ba |

193449
R Cygni

| | | | |
|---|---|---|---|
| 11 | 5 | 10.8 | Hu |
| | 11 | 11.4 | Ba |
| | 20 | 11.8 | Ba |
| | 26 | 10.8 | Hu |
| | 27 | 11.8 | Ba |

193509
RV Aquilae

| | | | |
|---|---|---|---|
| 11 | 9 | 11.7 | M |
| | 15 | 12.0 | Hr |
| | 28 | 12.5 | Ba |

193732
TT Cygni

| | | | |
|---|---|---|---|
| 11 | 1 | 7.5 | Ma |
| | 1 | 8.2 | R |
| | 5 | 7.9 | Hu |
| | 5 | 7.8 | Ma |
| | 9 | 7.8 | Ma |
| | 10 | 8.0 | Pi |
| | 12 | 8.1 | R |
| | 12 | 8.3 | M |
| | 20 | 7.4 | Ba |
| | 25 | 8.5 | Ma |
| | 28 | 7.4 | Ba |

194048
RT Cygni

| | | | |
|---|---|---|---|
| 11 | 1 | 7.6 | Ma |
| | 1 | 8.6 | R |
| | 3 | 7.5 | O |
| | 5 | 7.3 | Hu |
| | 5 | 7.8 | Ma |
| | 6 | 7.7 | Bu |
| | 7 | 7.8 | O |
| | 8 | 7.8 | Ly |
| | 9 | 8.0 | M |
| | 9 | 7.8 | Ma |
| | 11 | 7.8 | Ba |
| | 12 | 8.0 | R |
| | 20 | 8.1 | Ly |
| | 20 | 8.0 | Ba |
| | 25 | 8.5 | O |

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1915—Continued.

RT Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 25 | 8.3 | Ma |
| | 27 | 8.1 | Ba |
| | 30 | 8.8 | O |
| 12 | 3 | 9.1 | O |
| | 5 | 9.2 | O |

194348
TU Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 9.2 | R |
| | 6 | 9.0 | Ly |
| | 6 | 9.4 | Bu |
| | 9 | 9.5 | M |
| | 11 | 9.2 | Ba |
| | 12 | 9.2 | R |
| | 20 | 9.0 | Ly |
| | 20 | 8.8 | Ba |
| | 27 | 9.0 | Ba |
| 12 | 3 | 10.2 | O |

194632
χ Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 10.5 | E |
| | 3 | 10.4 | O |
| | 4 | 10.0 | R |
| | 5 | 9.9 | Hu |
| | 5 | 9.9 | M |
| | 6 | 10.4 | Bu |
| | 7 | 10.3 | O |
| | 11 | 9.5 | Ba |
| | 12 | 10.3 | R |
| | 12 | 9.8 | M |
| | 20 | 8.9 | Ba |
| | 25 | 10.2 | O |
| | 26 | 9.8 | Y |
| | 27 | 8.8 | Ba |
| | 28 | 10.0 | O |
| | 28 | 10.3 | Bu |
| 12 | 3 | 9.8 | O |
| | 5 | 9.8 | O |

195116
S Sagittae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 24.6 | 5.8 | Mu |
| | 25.5 | 5.7 | Mu |
| | 26.5 | 5.7 | Mu |
| | 29.5 | 5.6 | Mu |
| | 31.6 | 5.5 | R |
| 11 | 1.6 | 5.5 | R |
| | 1.6 | 5.6 | Ma |
| | 1.6 | 5.4 | Mu |
| | 2.4 | 5.7 | O |
| | 3.4 | 5.6 | O |
| | 3.6 | 5.8 | Mu |
| | 4.6 | 5.8 | R |
| | 5.5 | 6.0 | Mu |
| | 5.6 | 5.7 | Mu |
| | 6.5 | 5.7 | Ma |
| | 6.6 | 5.6 | Mu |
| | 7.4 | 5.4 | O |
| | 7.5 | 5.8 | Ma |
| | 7.6 | 5.5 | Mu |

S Sagittae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 9.5 | 6.0 | Ma |
| | 10.5 | 5.7 | R |
| | 11.6 | 5.7 | R |
| | 12.6 | 5.8 | R |
| | 17.5 | 5.4 | R |
| | 24.6 | 5.5 | Mu |
| | 25.5 | 5.4 | Ma |
| | 25.5 | 5.4 | Mu |
| 12 | 5.4 | 5.4 | O |
| | 7.4 | 5.7 | O |

195849
Z Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 6 | 12.5 | B |
| | 25 | 9.6 | |
| | 28 | 9.4 | Sp |
| | 28 | 9.6 | Ba |
| 12 | 3 | 9.4 | Y |

200357
S Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| | 25 | 9.4 | |

200647
SV Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 9.3 | Ma |
| | 4 | 9.5 | R |
| | 5 | 9.3 | Ma |
| | 5 | 8.6 | Hu |
| | 6 | 9.1 | Ly |
| | 9 | 9.1 | Ma |
| | 12 | 9.0 | Ly |
| | 12 | 9.3 | M |
| | 20 | 9.0 | Ly |
| | 20 | 8.3 | Ba |
| | 25 | 9.2 | Ma |
| | 25 | 9.4 | Pi |
| | 27 | 8.9 | Ly |
| | 28 | 8.6 | B |
| | 28 | 8.6 | Ba |

200715a
S Aquilae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 10.1 | R |
| | 9 | 10.1 | M |
| | 11 | 9.4 | Bu |
| | 20 | 9.7 | Ba |

200715 b
RW Aquilae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 9.0 | R |
| | 4 | 9.2 | R |
| | 9 | 9.4 | M |
| | 10 | 9.2 | R |
| | 11 | 9.3 | R |
| | 11 | 9.0 | Bu |
| | 12 | 9.2 | R |
| | 20 | 9.4 | Ba |

200812
RU Aquilae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 9.6 | B |
| | 11 | 9.0 | Bu |
| | 26 | 10.4 | Y |

200916
R Sagittae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 8.6 | R |
| | 9 | 7.8 | M |
| | 20 | 9.0 | Ba |

*200906*
Z Aquilae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 26 | 10.1 | B |

200938
RS Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 7.4 | Ma |
| | 4 | 7.4 | R |
| | 5 | 7.5 | Ma |
| | 5 | 8.6 | M |
| | 6 | 7.3 | Pi |
| | 6 | 7.4 | Bu |
| | 9 | 7.5 | Ma |
| | 12 | 7.3 | Ly |
| | 20 | 7.2 | Ly |
| | 20 | 7.3 | Ba |
| | 25 | 7.6 | Ma |
| | 25 | 7.5 | Pi |
| | 27 | 7.3 | Ly |

201008
R Delphini

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 13.0 | B |

*201121*
RT Capricorni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 7.8 | R |
| | 21 | 6.6 | Ba |

201647
U Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 8.5 | R |
| | 6 | 8.0 | Mu |
| | 6 | 7.9 | Pi |
| | 10 | 8.2 | Mu |
| | 11 | 8.8 | Bu |
| | 12 | 8.2 | M |
| | 12 | 8.3 | Ly |
| | 20 | 7.5 | Ba |
| | 25 | 7.6 | Pi |
| | 27 | 8.5 | Ly |
| | 30 | 7.9 | S |
| 12 | 5 | 7.3 | O |

202539
RW Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 30 | 9.4 | Ma |
| 11 | 4 | 8.7 | R |
| | 5 | 9.4 | Ma |
| | 5 | 9.2 | M |
| | 6 | 9.2 | Pi |

RW Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 9 | 9.1 | Ma |
| | 9 | 9.5 | M |
| | 10 | 8.8 | Ph |
| | 12 | 9.1 | Ph |
| | 12 | 9.0 | Ly |
| | 20 | 8.7 | Ba |
| | 25 | 9.2 | Ma |
| | 25 | 9.1 | Pi |
| | 27 | 9.1 | Ly |

202946
SZ Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 10.2 | R |
| | 4 | 10.3 | R |
| | 5 | 8.6 | Hu |
| | 5 | 9.2 | M |
| | 9 | 9.3 | M |
| | 10 | 10.0 | R |
| | 11 | 10.3 | R |
| | 12 | 10.6 | R |
| | 20 | 9.0 | Ba |
| | 21 | 8.8 | Ba |
| | 22 | 8.6 | Ba |
| | 26 | 9.3 | Ba |
| | 27 | 9.5 | Pi |
| | 27 | 9.4 | Ba |
| | 28 | 9.5 | Ba |

202954
ST Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 6 | 10.1 | B |
| | 9 | 10.2 | Hu |
| | 11 | 9.5 | Bu |
| | 27 | 11.2 | Pi |
| | 28 | 11.3 | B |

203226
V Vulpeculae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 7 | 8.5 | Pi |
| | 7 | 8.7 | O |
| | 20 | 9.0 | Ba |
| | 26 | 8.9 | O |
| | 28 | 9.1 | Ba |

203611
Y Delphini

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 12.6 | B |
| | 10 | 12.4 | Y |
| | 28 | 13.0 | B |
| 12 | 3 | 12.6 | Y |

203816
S Delphini

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 10.5 | Pi |
| | 10 | 10.8 | Y |
| | 28 | 9.8 | Pi |
| 12 | 3 | 9.9 | Y |

203847
V Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 5 | 9.6 | M |
| | 6 | 8.6 | B |
| | 11 | 8.8 | Bu |
| | 20 | 8.4 | Ba |
| | 25 | 8.3 | B |
| | 28 | 8.3 | Ba |

204016
T Delphini

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 12.5 | Y |
| | 28 | 10.6 | Pi |
| 12 | 3 | 13.0 ± | Y |

204318
V Delphini

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 9.4 | B |
| | 3 | 10.5 | O |
| | 10 | 9.9 | Y |
| | 20 | 10.1 | Ba |
| | 28 | 10.7 | O |
| | 28 | 10.1 | B |
| | 28 | 10.1 | Ba |

*204405*
T Aquarii

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 8.9 | B |
| | 4 | 9.4 | R |
| | 6 | 9.0 | Hu |
| | 6 | 9.1 | B |
| | 21 | 10.8 | Ba |
| | 28 | 11.0 | Ba |

204846
RZ Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 11.1 | Y |
| 12 | 3 | 11.3 | Y |

205017
X Delphini

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 12.3 | B |
| | 10 | 12.8 | Y |
| | 28 | 13.0 | B |
| 12 | 3 | 13.0 | Y |

205923
R Vulpeculae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 5 | 11.6 | Hu |
| | 12 | 9.2 | M |

*210116*
RS Capric.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 8.3 | R |
| | 21 | 8.0 | Ba |
| | 28 | 8.5 | Pi |

210382
X Cephei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 9.8 | Y |

VARIABLE STAR OBSERVATIONS Nov.-Dec., 1915—Continued.

210868
T Cephei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 6.8 | Pi |
| | 4 | 7.2 | R |
| | 7 | 6.5 | Ma |
| | 7 | 6.7 | Hu |
| | 11 | 6.6 | Bu |
| | 16 | 6.5 | Nt |
| | 20 | 6.6 | Ly |
| | 20 | 6.4 | Ba |
| | 25 | 6.5 | Ma |
| | 27 | 6.3 | Pi |
| | 28 | 6.2 | Nt |
| | 30 | 6.2 | O |
| 12 | 2 | 6.5 | S |

211614
X Pegasi

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 28 | 13.7 | Ba |

213244
W Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 6.9 | R |

213678
S Cephei

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 11.0 | Pi |
| | 7 | 10.0 | Hu |
| | 20 | 9.8 | Ba |
| | 27 | 10.8 | P |

213753
RU Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 4 | 8.5 | R |
| | 5 | 8.1 | M |
| | 22 | 7.5 | Ba |

213843
SS Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 29.7 | 9.4 | E |
| 11 | 1.6 | 11.1 | M |
| | 2.7 | 11.0 | E |
| | 3.5 | 11.7 | Ba |

SS Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 5.6 | 11.8 | Hu |
| | 6.4 | 11.5 | Pi |
| | 6.4 | 11.9 | Hu |
| | 6.5 | 11.8 | Nt |
| | 6.5 | 11.4 | Ly |
| | 6.6 | 11.8 | B |
| | 7.5 | 11.6 | Hu |
| | 7.5 | 11.7 | Nt |
| | 8.7 | 11.4 | E |
| | 9.5 | 11.7 | Ba |
| | 10.5 | 11.9 | Hu |
| | 10.5 | 11.9 | Pi |
| | 12.5 | 11.6 | Ly |
| | 20.5 | 11.7 | Ly |
| | 20.5 | 11.8 | Ba |
| | 21.5 | 11.8 | Ba |
| | 22.5 | 11.8 | Ba |
| | 25.6 | 11.9 | B |
| | 26.5 | 11.8 | Ba |
| | 26.5 | 11.9 | Hu |
| | 26.6 | 12.0 | B |
| | 26.6 | 12.0 | Nt |
| | 27.5 | 11.8 | Ly |
| | 27.5 | 11.9 | Ba |
| | 27.5 | 11.9 | Pi |
| | 28.5 | 11.9 | Pi |
| | 28.5 | 11.8 | Sp |
| | 28.5 | 11.6 | B |
| | 28.5 | 11.6 | Ba |
| | 30.6 | 11.9 | Nt |

213937
RV Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 8.7 | Ma |
| | 4 | 8.4 | R |
| | 5 | 8.5 | Ma |
| | 5 | 8.1 | Hu |
| | 5 | 8.7 | M |
| | 7 | 8.6 | Ma |

RV Cygni

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 7 | 8.3 | Pi |
| | 9 | 8.6 | Ma |
| | 12 | 9.0 | M |
| | 20 | 7.5 | Ba |
| | 25 | 8.6 | Ma |

214024
RR Pegasi

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 7 | 12.7 | Sp |

215934
RT Pegasi

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 9.8 | Y |

220714
RS Pegasi

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 10.0 | Y |

222439
S Lacertae

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 20 | 10.5 | Ba |
| | 28 | 11.1 | Ba |

*225120*
S Aquarii

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 8.8 | Ma |
| | 5 | 8.9 | Ma |
| | 7 | 8.6 | Hu |
| | 17 | 8.3 | Ma |
| | 20 | 8.5 | Ba |
| | 28 | 8.3 | Ba |

225914
RW Pegasi

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 31 | 11.0 | Mu |
| 11 | 6 | 10.8 | Mu |
| | 10 | 10.6 | Mu |
| | 22 | 12.3 | Ba |
| | 26 | 10.9 | Mu |
| | 28 | 11.1 | Ba |

230110
R Pegasi

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 1 | 9.4 | Ma |
| | 2 | 9.3 | O |
| | 6 | 9.2 | Ma |
| | 6 | 9.2 | Pi |
| | 7 | 9.0 | O |
| | 10 | 8.6 | R |
| | 10 | 8.7 | Pi |
| | 10 | 8.7 | Ph |
| | 13 | 8.5 | Ph |
| | 20 | 7.2 | Ba |
| | 25 | 7.7 | O |
| | 25 | 7.9 | Ma |
| | 25 | 7.8 | Pi |
| | 28 | 7.4 | O |
| | 28 | 7.3 | Ba |
| | 30 | 7.3 | Pi |
| 12 | 3 | 7.5 | O |
| | 5 | 7.4 | O |

230759
V Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 1 | 7.5 | Pi |
| | 2 | 7.8 | O |
| | 7 | 7.9 | O |
| | 7 | 8.0 | Sp |
| | 10 | 7.5 | R |
| | 10 | 8.2 | Nt |
| | 20 | 8.0 | Ba |
| | 28 | 9.0 | O |
| | 28 | 8.4 | Ba |

231425
W Pegasi

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 6 | 11.3 | Hu |
| | 6 | 11.7 | Ly |
| | 12 | 11.8 | Ly |
| | 28 | 12.3 | Ba |

233335
ST Androm.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 29 | 9.6 | E |
| 11 | 6 | 9.9 | Ma |
| | 6 | 9.3 | Hu |
| | 6 | 9.5 | Pi |
| | 11 | 10.5 | Bu |
| | 12 | 10.1 | Ly |
| | 20 | 9.5 | Ba |
| | 28 | 10.1 | Ba |

*233815*
R Aquarii

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 10 | 29 | 8.5 | E |
| 11 | 5 | 8.8 | Ma |
| | 7 | 8.2 | Hu |
| | 9 | 8.8 | Pi |
| | 10 | 8.6 | R |
| | 22 | 8.6 | Ba |
| | 25 | 9.1 | Ma |
| | 28 | 8.7 | Ba |

*235209*
V Ceti

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 28 | 10.5 | Ba |

235350
R Cassiop.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 10 | 7.1 | R |
| | 10 | 7.3 | Nt |

235525
Z Pegasi

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 2 | 9.6 | O |
| | 7 | 9.8 | O |
| | 22 | 9.2 | Ba |
| | 25 | 9.7 | O |
| 12 | 3 | 9.5 | O |

235939
SV Androm.

| Mo. | Day | Est. | Obs. |
|---|---|---|---|
| 11 | 6 | 11.6 | Hu |
| | 6 | 12.3 | Sp |
| | 26 | 12.6 | Hu |
| | 28 | 12.6 | Sp |

No. of observations 919; No. of stars observed 179; No. of observers 20.

The Association is greatly indebted to Professor Pickering, and the members of the Observatory staff for their cordial reception, the many privileges extended, and the courtesies shown us which made the occasion ever memorable.

The following members were present: Messrs. Bouton, Burbeck, Hunter, McAteer, Nolte, Olcott, Pickering, Spinney, Steuart, and Wilson.

Mr. Burbeck deserves great credit for his successful and efficient management of the affair. He entertained several members at his observatory in North Abington.

Mr. McAteer brought greetings from the Allegheny Observatory, and on his way back to Pittsburg visited the Dudley Observatory at Albany, N. Y.

Members will kindly observe the variable *021403 o* Ceti at every opportunity, as Mr. Campbell is observing this star with the photometer. This will enable him to check up the probable error of the individual observers.

The irregular variables 060547 SS Aurigae, 074922 U Geminorum, and 213833 SS Cygni, should be constantly observed by every member.

The following members contributed to this report:—Messrs. Bancroft, Bouton, Burbeck, Crane, Eaton, Harrell, Hunter, Lindsley, Mach, McAteer, Mundt, Nolte, Olcott, Phillips, Pickering, Richter, Spinney, Miss Swartz and MissYoung.

WILLIAM TYLER OLCOTT,
Corresponding Sec'y.

Norwich, Conn.
Dec. 10, 1915.

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**Results of Variable Star Observations.**—Below I give the results of some of my observations of variable stars which you can insert in P. A. if you can find space.

| Variable | Designation | Phase | Date 1915 | Mag. | Number of Observations | First Observation Date 1915 | First Observation Mag. | Last Observation Date 1915 | Last Observation Mag. |
|---|---|---|---|---|---|---|---|---|---|
| S Urs. Maj. | 123961 | Max. | June 21 | 7.6 | 24 | Mar. 28 | 10.1 | Nov. 11 | 9.5 |
| " | " | Min. | Oct. 3 | 11.6 | | | | | |
| T Urs. Min. | 133273 | Max. | Sept. 16 | 9.2 | 11 | July 6 | 12.5 | Nov. 11 | 10.6 |
| SS Herculis | 162807 | Max. | Aug. 12 | 9.15 | 10 | June 17 | 12.8 | Sept. 27 | 12.3 |
| W Herculis | 163137 | Max. | July 7 | 8.4 | 11 | Apr. 4 | 12.7 | Oct. 3 | 12.2 |
| R Draconis | 163266 | Max. | July 30 | 7.2 | 21 | Apr. 6 | 12.0 | Nov. 28 | 11.6 |
| RV Herculis | 165631 | Max. | Aug. 7 | 11.2 | 6 | June 29 | 13.8 | Nov. 2 | 12.0 |
| W Lyrae | 181136 | Max. | Aug. 9 | 8.15 | 10 | June 17 | 9.9 | Oct. 27 | 12.3 |
| RV Aquilae | 193509 | Max. | Sept. 19 | 9.8 | 6 | July 24 | 12.7 | Nov. 28 | 12.5 |
| T Aquarii | *204405* | Max. | Sept. 19 | 7.3 | 8 | July 18 | 10.7 | Nov. 28 | 11.0 |
| S Lacertae | 222439 | Max. | Sept. 20 | 8.5 | 6 | Aug. 13 | 10.2 | Nov. 28 | 11.1 |

Total number of observations 113.

A curve was plotted for each star.

H. C. BANCROFT, JR.

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**α Orionis.**—Mr. F. E. Seagrave asks that we call attention to the great decrease in the light of Betelgeux (α Orionis). Early in December it was only slightly superior to Aldebaran (α Tauri), only .05 magnitude brighter. It was down to about where it was in February 1911.

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**Mira (*o* Ceti)** was bright, about third magnitude, during the early days of December. The position of this wonderful variable star is shown on the same chart with the apparent paths of the two comets (see page 72).

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## COMET AND ASTEROID NOTES.

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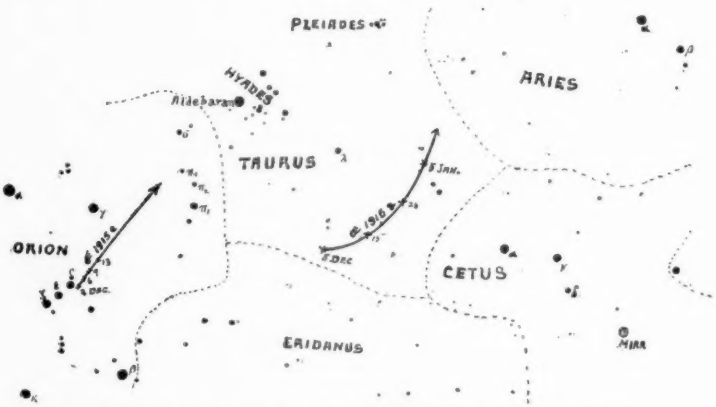
**Comet 1915 *a* (Mellish).**—The first comet of the year 1915, which went so far south during the summer months as not to be visible in our northern latitudes, is now north of the equator again and is moving slowly in the constellation Taurus. Its course for December is shown on the same diagram with that of the new comet 1915 *e* (Taylor). No ephemeris is at hand extending beyond January 5, but from the general curve of its path the reader can extend its course approximately through the month. This comet is still easily seen in a small telescope but will decrease rapidly in brightness during next month.

**New Comet 1915 *e* (Taylor).**—Harvard College Observatory Bulletin 592 announced the discovery of a new comet on December 2 by Taylor, at Cape of Good Hope. The announcement from Cape of Good Hope came by way of Greenwich and Copenhagen and was apparently delayed two or three days. On December 2 the comet was three minutes (of time) west and sixteen minutes (arc) south of δ Ori-




COMETS 1915 *a* (MELLISH), 1915 *e* (TAYLOR) AND MIRA (*o* CETI).

onis. It has since been moving very slowly almost directly northwest, toward Aldebaran. At the present rate of motion (Dec. 16) it will be in the vicinity of Aldebaran toward the end of January. The comet is not a conspicuous object in the telescope but is easily seen with our 5-inch finder. The accompanying diagram shows the apparent course during December.

The following observations have come to hand.

| Greenwich Mean Time | R. A. | Dec. | Observer | Place |
|---|---|---|---|---|
| | h m s | ° ′ ″ | | |
| Dec. 6.6957 | 5 22 42.9 | +0 01 36 | Burton | Washington |
| 6.7597 | 22 40.31 | 0 02 10.5 | Van Biesbroeck | Williams Bay |
| 7.6577 | 22 11.58 | 0 12 06.4 | Wilson | Northfield |
| 7.7719 | 22 07.5 | 0 13 24 | Van Biesbroeck | Williams Bay |
| 7.8892 | 22 04.7 | 0 14 37 | Aitken | Mt. Hamilton |
| 8.7004 | 21 36.8 | 0 24 05 | Burton | Washington |
| 9.6817 | 21 03.30 | 0 36 02.5 | Wilson | Northfield |
| 13.7012 | 5 18 39.71 | +1 30 23.9 | Wilson | Northfield |

The following elements and ephemeris were computed by Miss Levy and Mr. Shane of the Student's Observatory, Berkeley, California, from observations on December 7, 8 and 9. They were telegraphed to Harvard College Observatory and from there distributed in Bulletin 595, issued December 13.

ELEMENTS OF COMET 1915 *e* (TAYLOR).

$T$ = 1915 November 4.84 Gr. M. T.
$\omega$ = 315° 55′
$\Omega$ = 107 44
$i$ = 27 09
$q$ = 2.543

These elements are very uncertain because of the very slow movement of the comet.

EPHEMERIS.

| | | R. A. | Dec. | Light |
|---|---|---|---|---|
| | | h m s | ° ′ | |
| 1915 Dec. | 12.5 | 5 19 25 | + 1 11 | 0.99 |
| | 16.5 | 5 17 07 | 2 03 | |
| | 20.4 | 5 14 53 | 2 59 | |
| | 24.5 | 5 12 47 | +3 56 | 0.94 |

## GENERAL NOTES.

**Mr. G. Van Biesbroeck,** who is spending this year at the Yerkes Observatory, intends to undertake the discussion of the observations of comet 1913 *f* (Delavan). He requests that unpublished observations of the comet be communicated to him as soon as possible.

**Dr. R. W. Wood,** professor of physics at Johns Hopkins University, has returned to Baltimore from the Mount Wilson Observatory, where he has been engaged in photographing the moon, Saturn and Jupiter by yellow light and ultra violet and infra red rays. (*Science* Dec. 3, 1915).

**Professor S. A. Mitchell,** director of the Leander McCormick Observatory, lectured at the Brooklyn Institute of Arts and Sciences on November 20, on "The Exact Distances of the Stars." On November 22 he lectured in Harrisburg before the Natural History Society on "The Sun."

**Carl Axel Robert Lundin,** who as a member of the firm of Alvan Clark & Sons had a large share in making several of the largest telescopic lenses in the world, died at his home in Cambridge on November 28.

**Professor John A. Miller,** director of the Sproul Observatory of Swarthmore College, has been chosen to give the Westbrook lectures before the Wagner Institute of Free Science in Philadelphia. This is a course of five lectures to be given in February and March. The general subject will "Aspects of Modern Astronomy."

**New Edition of Boss' Catalogue.**—From the *Bulletin Astronomique* we learn that the Carnegie Institution of Washington has decided to publish a new edition, by photographic reproduction, of the "Preliminary General Catalogue of 6188 Stars" the first edition of which has been exhausted for some time.

**New Observatory for Duluth, Minnesota.**—We learn from *The Duluth Herald* of December 3 that Mr. John H. Darling of Duluth, Minnesota, has promised to build an observatory on one of the public playgrounds of that city. It is to be built as a private observatory, but is to be open at stated times to those interested in astronomy. It is said to be Mr. Darling's plan to turn over the observatory either to the city or to some educational institution that will care for it after his death. It is planned to erect a brick structure, with a 20-foot dome and an adjoining library, the building to cost approximately $3000. The telescope is to be a 9-inch refractor, equatorially mounted and clock driven, to cost $3000.

**Observed Rotations of Planetary Nebulae.**—In *Publications of the Astronomical Society of the Pacific* No. 161, December 1915, Professor Campbell and Mr. J. H. Moore of the Lick Observatory announce that they have obtained spectrograms of the planetary nebula N. G. C. 7009 (R. A. $20^h\ 58^m$, Dec. $-11°\ 48'$), which yield positive proof of rotation of the nebula. When the slit of the spectrograph was placed parallel to the major axis of the nebula the lines were inclined with reference to the lines of the comparison spectrum; when the slit was parallel to the minor axis of the nebula no inclination of the lines was indicated.

"The ends of the lines corresponding to the west edge of the nebula are displaced to the violet with reference to the ends corresponding to the eastern edge of the nebula. The interpretation is that the rotation of the nebula is carrying the western edge toward us and the eastern edge away from us. The maximum rotational speed appears to be at approximately 9 seconds of arc from the center of the nebula and is in amount 6 kilometers per second. The extreme outer ends of the spectrum lines do not maintain their inclination at the full rate, but turn back slightly. This we interpret to mean that the law of rotation is such that the outer strata lag behind."

It is announced that positive evidence of rotational effects have been secured in the cases of two other nebulae, and suspected evidence in other cases.

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**A Meteor Star Atlas.**—A very convenient star atlas for meteor observation has been published as *Publications of the Dominion Observatory, Ottawa*, Vol. II, No. 7. It consists of 20 maps of portions of the sky, drawn by Dr. Reynold K. Young. The maps are constructed on the gnomonic or central projection so that areas of great circles across them are represented by straight lines. This atlas will be found very useful for the purpose of plotting meteor trails.

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**Orbits of Spectroscopic Binaries.**—Numbers 8 and 9 of Volume II of the publications just referred to contain orbits of the spectroscopic binaries 1149 Groombridge and 23 Cassiopeiæ, the former orbit calculated by W. E. Harper and the latter by Reynold K. Young.

ELEMENTS.

| | 1149 Groombridge | 23 Cassiopeiæ |
|---|---|---|
| $T$ | = J. D. 2,419,341.776 ± 0.663 | 2,420,577.41 ± 0.27 |
| $K$ | = 67.19 km ± 1.19 | 16.32 km ± 0.50 |
| $\omega$ | = 152°.9 ± 24°.2 | 269°.71 ± 4°.10 |
| $e$ | = 0.081 ± 0.027 | 0.405 ± 0.026 |
| $\gamma$ | = − 13.74 km ± 1.39 | −4.06 ± 0.34 |
| Period | = 9.944 days | 33.75 days |
| $a \sin i$ | = 9,127,000 km | 7,020,000 km |

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**Radial Velocities of Six Nebulae.**—In *Publications of the Astronomical Society of the Pacific* No. 161, December 1915, Mr. Francis G. Pease gives the results of the determination of the radial velocities of six nebulae with the 60-inch Cassegrain spectrograph of the Mount Wilson Observatory. For the Dumb-bell nebula the exposure was 32½ hours, extending over five nights; for Messier 33 the exposure was 34½ hours. In each of these cases the slit was set on the brightest knot in the nebula.

| | Velocity |
|---|---|
| Dumb-bell Nebula | − 63 km |
| Messier 33 | −278 " |
| N. G. C. 7023 | + 0.7 " |
| N. G. C. 6572 (planetary nebula) | − 12 " |
| N. G. C. 6826 " " | − 8 " |
| N. G. C. 6891 " " | + 38 " |

**An Introduction to the Study of Variable Stars.**—By CAROLINE E. FURNESS, Ph. D., Director of the Vassar College Observatory. Houghton Mifflin Company, 1915. 12 mo., pp. xv + 327 with 14 plates and 36 figures in the text. $1.75 net (weight 30 oz).

This important work is "One of a collection of notable volumes by Vassar alumnae, published in commemoration of the fiftieth anniversary of America's oldest college for women." The author had been a teacher of Astronomy at Vassar for several years in connection with Professor Mary W. Whitney, and since Miss Whitney's retirement, is Professor of Astronomy and Director of the Observatory. The observation of variable stars has been carried on at Vassar for the past fourteen years and the author's work in this department has prepared her for the preparation of this book.

The most superficial reading of the book impresses one with an idea of its completeness and thoroughness of treatment, and leads to the remark that the title "Introduction" is perhaps excess of modesty, for the quality and quantity of the book entitles it to rank with works bearing more ambitious titles.

The work treats of all the subjects which one would naturally connect with the study of variable stars, and in addition goes into considerable detail in descriptions of the principles of spectrum analysis and the relation between the spectra of variable stars and their class of variation. It also describes in detail the principles underlying the different photometric instruments, the principles of photo-electric action and of radial velocity. As a result the student of this book can gain not only the methods of variable star observations, but also the meaning of the phenomenon of variation as interpreted by the modern theories of Astrophysics.

This work will naturally be compared with that of Hagen, of which the first two parts have already appeared. While it necessarily covers the same ground as Hagen's work, with similar treatment to some extent, yet it differs from his in several particulars, mainly in the points already mentioned, the inclusion of fundamental principles, and the extension to photographic and photo-electric methods. The author states that her work is "An introduction rather than a handbook and as such devotes more space to explanatory material than to an intensive treatment of results of research."

The first chapter is introductory, and treats in a provisional way of stellar variation, the representation of the elements of variation, the classes of variables, the principles of spectrum analysis, the relation between the spectral classes and the different kinds of variation. The reading of this chapter will thus give a good preparation for the more detailed treatment of the different points, given in the following fourteen chapters.

These fourteen chapters fall naturally into four divisions.

1. The observers equipment (chapters 2 to 5), maps, charts, catalogs, meaning of the term magnitude. (This corresponds to Part 1 in Hagen's work).

2. Photometry of variables (chapters 6 to 8), visual, photographic, photo-electric.

3. Use of the observations (chapters 9 to 11), light-scale, light-curves, elements of variation and predictions from elements.

4. Deductions from the data in the preceding chapters (chapters 12 to 15), eclipsing binary variables, long period variables, statistics of stellar variation, hints to observers, tables.

The many variable star observers both amateur and professional, who read and report to POPULAR ASTRONOMY, will find this book indispensable in their work. Chapter XV, "Hints for Observers" gives valuable directions in regard to the "(1) Use of telescope; (2) Time; (3) Identification of variable; (4) Methods of recording; (5) Precautions; Stars suitable for observers with different apertures, mounted and

unmounted." A regard for these directions, which show the author to be experienced both as an observer and teacher, will save much trouble and uncertainty.

Chapters IX, "Formation of Light-Scale," and X, "Mean Light Curve," will enable the observer to reduce and plat his own observations. This will not only give his results in a more useful form, but will also add greatly to his independence and accuracy as an observer. It is no doubt useful to have the observation turned over to a central bureau even in a raw state, so to speak, but it is greatly to be desired that the observer should progress as fast as possible towards the condition in which he can turn out a finished product, and thus have a standard of his own by which to judge of his observations. To the reviewer, this seems to be the most valuable result which may be hoped from the study of this work.

One of the most interesting recent discoveries from the observations of variable stars, is that the color deepens as the minimum is approached. This change is pretty well established for variables of the Cepheid type, and probably established for variables of long period. This change is most conveniently found from a comparison of visual and photographic light-curves. From the theoretical side this discovery is the most promising hint towards an explanation of the cause of variation of these types. The author seems to have omitted reference to this phenomenon, the only important omission, perhaps, in the book. Nevertheless, the variable-star work which the book will do so much to further, will furnish valuable data, especially from the visual side, for a comparison of visual and photographic curves, and therefore a test of the prevalence of this change in color.

With no desire to detract from the worth of the book, a few items may be mentioned, which from the standpoint of the reviewer might be modified to advantage. (1) The engravings of stellar spectra, Plates X, XI, XIII and XIV have no wave lengths on the margins, or anything to indicate the included range. This is rather puzzling to one who is not quite familiar with photographic spectra. (2) There is nothing to indicate the source of plates X and XI "Spectra of $\zeta$ Ursae Majoris and $\mu$ Orionis," which are evidently taken from the Bruce Spectrograms of the Yerkes Observatory. The spectrum of $\zeta$ Ursae Majoris is printed as usual with the red end of spectrum toward the right, while that of $\mu$ Orionis is reversed in direction. (3) Chapter V, "Stellar Magnitudes" lacks the important definition of "absolute magnitude", that is, the magnitude a star would appear to have if removed to a standard distance, 33 light-years, corresponding to a parallax of one-tenth of a second of arc. (4) On page 141 halation circles are mentioned as peculiar to refractor images and the statement is made that "this occurs only with a bright star, and cannot be avoided, ordinarily." It scarcely needs to be stated that this trouble is also present with reflector images, and can always be avoided by backing the plates.

The publishers, as usual, have done their work well. Good paper, large type, clear engravings and cuts, make a handsome volume which is worthy of high praise, both for its comprehensive plan and for the thoroughness and good judgment shown in carrying it out. It probably can be regarded as rather a supplement than a rival to Hagen's larger work, and is the only one of its class in any language, known to the reviewer. To foreign readers it may seem open to the criticism of being written too much from an American point of view, although it gives much space and credit to the work of the German pioneers and to the coöperation of the amateur observers in the British Astronomical Association. It should be found in every astronomical library and will doubtless be used in most of the schools where practical astronomy is taught. Vassar College is to be congratulated on the publication of such scholarly works in celebration of their fiftieth anniversary.

J. A. PARKHURST.